WEST COAST DISTRICT MUNICIPALITY

AIR QUALITY MANAGEMENT PLAN

GONDWANA
ENVIRONMENTAL SOLUTIONS

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EXECUTIVE SUMMARY

1. VISION, MISSION AND OBJECTIVES

The vision, mission, goals and objectives developed for the West Coast District Municipality reflects the vision, mission and general approach for air quality management at the National, Provincial and Local levels. The National Framework for Air Quality Management was reviewed during this process to ensure the District is in line with National requirements.

2. INTRODUCTION

The National Environmental Management: Air Quality Act 39 of 2004 (AQA) requires Municipalities to introduce Air Quality Management Plans (AQMP) that set out what will be done to achieve the prescribed air quality standards. Municipalities are required to include an AQMP as part of its Integrated Development Plan.

2.1 Geographic Overview

The West Coast District Municipality is located in the Western Cape Province in South Africa. The District is comprised of five Local Municipalities, namely, Bergrivier, Cederberg, Matzikama, Saldanha Bay and Swartland, as well as three District Management Areas. The District as a whole is mainly comprised of agricultural activities including wheat and potato fields, vineyards and fruit orchards. The unique flora and picturesque landscape of this area encourage tourism in the District Local industries comprise mostly of metal processing and fish meal production.

The main objective of the project is to develop an Air Quality Management Plan for the West Coast District Municipality, as per the requirements of the Air Quality Act of 2004.

2.2 Methodological Approach for the development of a Status Quo (Situation) Assessment for the West Coast District Municipality

The development of a Status Quo Assessment was undertaken in a phased approach, which included the following:

- ***Literature Review* –** this phase includes a detailed review of local and international legislation with particular emphasis on the new National

Environmental Management: Air Quality Act. The national air quality standards were reviewed as well as applicable international guidelines and standards. Health impacts associated with criteria pollutants have also been discussed in detail. The Western Cape Provincial Government Air Quality Management Plan Guideline, DEA's Draft Air Quality Management Planning Manual and the Western Cape Climate Change Strategy and Action Plan have also been included in this review.

- ***Baseline Characterisation*** – this phase included the assessment of the ambient air quality and prevailing meteorological conditions within the District. Meteorological data was obtained from the South African Weather Service (SAWS) and Agricultural Research Council (ARC) which was analysed and used as input for the dispersion model. All available air quality monitoring data are to be collected from government and industry and should include continuous monitoring data, passive sampling campaigns and dust fallout.
- ***Emissions Inventory*** – this phase of the assessment includes the compilation of an emissions inventory. This information will form the framework of an emissions inventory database which will need to be updated during the implementation phase of the AQMP. The emissions inventory for the WCDM was compiled through a review of previous studies done in the area, availability of existing emissions databases as well as questionnaires. Where data could not be collected through these methods (i.e.: informal settlements, waste disposal and traffic) emissions were quantified by means of emission factors and internationally accepted methodologies. The Emissions Inventory for industrial sources is included in section 6. (Table 18)
- ***Dispersion Modelling*** – major sources of pollution identified by the emissions inventory are to be grouped into class, significance and associated impact. This information was then fed into a dispersion model. Modelling simulations determine the pattern of impact of criteria pollutants from these sources, as well as their compliance with the national standards.

  The United Kingdom Department of Environment, Food and Rural Affairs approved model, ADMS 4 was used.

3. POLICY AND REGULATORY REQUIREMENTS

3.1 Air Pollution Prevention Act 45 of 1965

The Atmospheric Pollution Prevention Act 45 of 1965 (APPA) focuses mainly on source based control with registration certificates issued for Scheduled Processes. This legislation made provision for the control of noxious or offensive gases from Scheduled Processes which are subject to the Best Practicable Means (BPM) of pollution abatement. The Chief Air Pollution Control Officer (CAPCO) of DEA was responsible for the implementation of the BPM approach. Control of smoke emissions was enforced by local authorities through regulation and smoke control zones. Dust emissions from mining and quarrying activities were also controlled and enforced by the CAPCO as well as by the Department of Minerals and Energy through the inspection of mines. Provision was also made for the control of vehicle exhaust emissions. However, APPA is out dated and has been replaced with the Air Quality Act 39 of 2004 (AQA) which came into effect on 11 September 2005 and has been in full effect since 1 April 2010.

3.2 National Environmental Management: Air Quality Act 39 of 2004

The National Environmental Management: Air Quality Act 39 of 2004 has shifted the approach of air quality management from source-based control to receptor-based control. The Act made provision for National ambient air quality standards, however it is generally accepted that more stringent standards can be established at the Provincial and Local levels. Emissions are controlled through the listing of activities that are sources of emission and the issuing of emission licences for these listed activities. Atmospheric emission standards have been established for each of these activities and an atmospheric licence is now required to operate. The issuing of emission licences for Listed Activities will be the responsibility of the Metropolitan and District Municipalities. Municipalities are required to *'designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality'*. The appointed Air Quality Officer will be responsible for the issuing of atmospheric emission licences or the Air Quality Officer could delegate the responsibility to a senior official such as a Municipal Manager or Environmental Health Manager.

3.3 Legislation for Local Government

The Local Government: Municipal Systems Act 32 of 2000, together with the Municipal Structures Act 117 of 1998, establishes local government as an autonomous sphere of government with specific powers and functions as defined by the Constitution. Section 155 of the Constitution provides for the establishment of Category A, B and C municipalities each having different levels of municipal executive and legislative authorities. According to Section 156(1) of the Constitution, a municipality has the executive authority in respect of, and has the right to, administer the local government matters (listed in Part B of Schedule 4 and Part B of Schedule 5) that deal with air pollution.

3.4 Local Air Quality By-Laws

Currently there are no air quality By-laws being enforced within the West Coast either at district or local levels. The Department of Environmental Affairs has developed a draft generic air pollution control By-law for Municipalities. It is proposed that this model created by the Department of Environmental Affairs be used as a structure to create a By-law for the WCDM by adapting the model By-law to be applicable to the WCDM. (A Draft Air Quality By-Law for WCDM has been compiled).

3.5 Ambient Air Quality Guidelines and Standards

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and well-being (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. The South African Bureau of Standards (SABS), in collaboration with DEA, established ambient air quality standards for criteria pollutants. Two standards were published as part of this process and they are discussed in section 3.5.

4 CRITERIA POLLUTANTS AND ASSOCIATED HEALTH AND ENVIRONMENTAL EFFECTS

An overview of the potential human health and environmental impacts associated with air pollutants is given. The Western Cape Province has developed the Western Cape Provincial Climate Change Response and Action Plan Strategy to address the potential

impacts associated with climate change in the Province. The response strategy and action plan aims to strengthen the Province's resilience to climate change and its adaptive capacity and aims to maintain the Province's status as a relatively low greenhouse gas emitter by reducing the Provincial carbon footprint (OneWorld Sustainable Investments, 2007).

Air quality can be sensitive to increased temperatures, increased greenhouse gas emissions as well as an increased demand for local fuels. Impacts associated with climate change and the failure to implement mitigation measures may result in increased air pollution episodes. Measures to address climate change include increasing the number of monitoring stations in the Western Cape, effectively dissemination air quality information and introducing cleaner fuel programmes for households and transport.

5. METEOROLOGICAL OVERVIEW AND AMBIENT AIR QUALITY OF THE WEST COAST DISTRICT

5.1- 5.3 Meteorological Overview

Surface meteorological data was obtained from SAWS and ARC who operate meteorological stations in the District as part of larger National Meteorological Monitoring Networks. Based on the available meteorological data, significant variation in the wind field is observed in the West Coast indicative of the strong underlying topographical influence on the prevailing meteorological conditions. Monitoring data was also received from the Port of Saldanha air quality monitoring station. (Figure 21 and Figure 22) Local meteorological conditions in the district are evaluated using surface meteorological data from weather stations operated by SAWS and ARC. Meteorological parameters were obtained for eight stations for the period January 2006 to December 2009.

5.4 Current Ambient Air Quality Situation

Continuous monitoring campaigns are mostly run by industry. ArcelorMittal Vredenburg, Exxaro Namakwa Sands and the Port of Saldanha operate monitoring stations. Data was received from the Port of Saldanha and ArcelorMittal. The Western Cape Provincial Government also operates an ambient network of four mobile stations where NO_2, SO_2, O_3, PM10, CO and CO_2 are measured. One station was situated at Vredenburg and has recently been relocated to Malmesbury. This data is discussed. The other three are

located outside the West Coast District. A map indicating the locations of the meteorological stations is included in section 4 (Figure 8 and Figure 17).

6 STATUS QUO OF THE AMBIENT AIR QUALITY IN THE WEST COAST

6.1 Current Ambient Air Quality Situation

Ambient air quality monitoring information that was received for the District was collated and is discussed in this section. Continuous monitoring campaigns are mostly run by industry. ArcelorMittal, Exxaro Namakwa Sands and the Port of Saldanha operate monitoring stations and have been contacted for data. Data was received from the Port of Saldanha and ArcelorMittal. The Western Cape Provincial Government also operates an ambient network of four mobile stations where NO_2, SO_2, O_3, PM_{10}, CO and CO_2 are measured. One station was situated at Vredenburg and has recently been relocated to Malmesbury. Data was received for the Vredenburg station before it was moved to Malmesbury; the data for the relocated station was requested but not received. The other three are located outside the West Coast District.

6.2 Baseline Emissions Inventory

An emissions inventory for the West Coast has been compiled for air pollution sources where information is available or where emission factors can be applied to quantify emissions. Potential air pollution sources in the West Coast have been identified as:

- *Industrial operations* - mainly emissions from small boiler sources and larger industry such as steel processing, cement manufacturing and fishmeal production in the District.
- *Agricultural activities* - although not quantified, agricultural activities are considered to be a contributor to ambient particulate concentrations. Agriculture is a dominant land-use within many areas of the West Coast District.
- *Mining Activities* – Mining activities, like Port of Saldanha Iron ore, are a contributor to pollution. Pollution sources are mainly surface activities like waste loading and unloading, iron ore loading and unloading, exposed screening plants waste dumps, stock yards, exposed pit surfaces, transport roads and haul roads which are major contributors to particulate matter concentrations.

- *Biomass burning (veld fires)* - also not quantified due to the irregular and seasonal nature of this source, but also considered to be an important contributor to ambient particulate concentrations, particularly during the fire season.
- *Domestic fuel burning* - mainly wood and paraffin burning in informal settlements. These settlements are mostly situated around larger towns such as Vredendal, Malmesbury, Clanwilliam and Piketberg. Cederberg and Matzikama Municipalities are the largest contributors to domestic fuel burning emissions in the District, mainly due to the predominant use of wood in these Municipalities.
- *Vehicle tailpipe emissions* - from petrol and diesel vehicles along major roads in the District. Compared to other areas such as Cape Town and Johannesburg, vehicles are not considered to be a significant air pollution source.
- *Waste Treatment and Disposal* – information regarding disposal facilities (landfills and incinerators) in the West Coast District has been partially collected.
- *Vehicle entrainment of dust from paved and unpaved roads*,
- *Other fugitive dust sources such as wind erosion of exposed areas*.

Particulate and gaseous emissions from industrial operations, domestic fuel burning and vehicle tailpipe emissions have been quantified for this assessment.

A list of facilities and a map with the location of the facilities are included in section 6. (Figure 23 and Table 6)

6.3 Predicted Ambient Air Quality in the West Coast District

Dispersion modelling simulations of PM_{10}, SO_2 and NO_2 emissions from quantifiable industrial sources for the southern portion of the West Coast District were undertaken using ADMS 4. Modelled concentrations are presented as isopleths plots for the highest hourly and daily averages. It should be noted that the isopleths plots of the hourly and daily averages contain only the maximum predicted ground-level concentrations, for those averaging periods, over the period for which the simulations were undertaken.

Dispersion modelling simulations indicate that the main area of impact occurs in the Saldanha Bay Local Municipality, corresponding with heavy industry. The dispersion modelling in this area indicates that although it is the heaviest industry, the highest concentrations of pollution recorded are still well below the national standards.

7 AIR QUALITY PRACTICES AND INITIATIVES WITH PROVINCIAL AND LOCAL GOVERNMENT

7.1 Government Structure and Functions

The capacity for air quality management and control within the West Coast District is assessed within the various spheres of Government. The current capacity at Provincial, District and Local levels is evaluated in terms of available personnel, functions and resources.

7.1.1 Provincial Level

Within the Western Cape Province, the Director of Pollution Management is responsible for air quality related functions. Within this Department, the Director of Pollution and the Provincial Air Quality Officer play a direct role in air quality management and control. Air quality is primarily a function of the Air Quality Management Deputy Directorate: Pollution Management

7.1.2 District Level

Within the West Coast District Municipality, Municipal Health Services (MHS) in the Department of Directorate Corporate and Community Services is responsible for air quality management and control. Functions of Municipal Health Services also include some environmental services as described in the National Health Act 61 of 2003. These include water quality monitoring, food control, waste management, health surveillance of premises, surveillance and prevention of communicable diseases, vector control, environmental pollution control, disposal of the dead and chemical safety.

7.1.3 Local Level

Limited or no dedicated Air Quality Officers are available at local level. There are currently only Environmental Health Practitioners that have air quality as one of their portfolios.

7.2 Air Quality Management Tools

Air quality management tools are limited to the maintenance of a complaints response database in the West Coast District. Limited knowledge and software exists for dispersion modelling in the District. Ambient air quality monitoring is only undertaken by Province in the District.

8 CAPACITY BUILDING WITHIN LOCAL GOVERNMENT

The current capability of the WCDM is limited by the shortage of personnel, skills and tools required for effective and co-ordinated air quality management. Air quality management is a relatively new function within the District as a whole, with few Local Municipalities able to undertake basic air quality functions. Air quality responsibilities are mainly limited to the investigation of public complaints and maintaining an inventory database. Where required and if within capability, air quality support is provided to the Local Municipalities by the District Municipality and by the Province.

8.1 Human Resources

Human resources required in the District Municipality include a dedicated, skilled Chief Air Quality Officer whose responsibilities are only related to air quality management and control. As and when ambient monitoring is undertaken in the District, a skilled, trained technician must be appointed in the District Municipality. Support for air quality management should continue to be provided to the District by the Province.

Within the Local Municipalities, it is also recommended that an Air Quality Officer be appointed in each of the Local Municipalities. However, given the resources and finances required for these appointments, it is recommended that, as a starting point, two other Air Quality Officers are appointed in the District to assist the Chief Air Quality Officer. Support should be provided to the Local Municipalities by the WCDM's Air Quality Officers.

8.2 Air Quality Management Tools

Air quality management tools are required in the District Municipality to effectively fulfill their air quality functions. Such tools include emissions inventory software, dispersion modelling software and air quality monitoring equipment. The first step in compiling an

emissions inventory for industrial and mining sources in the District has been included as part of this Plan. Province has an existing Emissions Inventory Database for point and area source and has future plans to expand Emission Inventory database to mobile sources. The WCDM has compiled a list of burning appliances and listed activities within the District but this list needs updating and completion. For effective air quality management and control, an accurate, electronic emissions inventory of point, non-point and mobile sources needs to be established, regularly updated and maintained. The District, in collaboration with Province, should complete and regularly update the emissions inventory. As and when dispersion modelling skills are available and needed a range of models are available either as freeware or to purchase. Appropriate models for the District could include ADMS-Urban (for smaller modeling domains in urban areas), AERMOD or CALPUFF (for larger, more complex modeling domains). Air quality monitoring options include continuous ambient air quality monitoring stations or passive sampling methods.

9 IMPLEMENTATION OF AIR QUALITY MANANGEMENT PLAN

9.1 Human Resources

A summary of the human resources needed within the WCDM is given and how it should be implemented.

9.2 Air Quality Management Tools

A summary of the human resources needed within the WCDM is given and how it should be implemented.

9.3 Ambient Air Quality Monitoring

A summary of the human resources needed within the WCDM is given and how it should be implemented.

9.4 Emissions Reduction/Control Strategies

Emissions reduction and control strategies are given for each sector that is a source of pollution in the District. Implementation of the strategies and who is responsible is also given with a few recommendations.

9.5 By-Law Promulgation

The Air Quality By-law created for the WCDM must be implemented and promulgated as soon as it is approved by the relevant authorities. A draft Air-Quality By-Law for WCDM has been compiled.

10 CONCLUSION AND WAY FORWARD

The Air Quality Management Plan for the West Coast District Municipality must be approved by Council and then be implemented within the WCDM. Municipalities are required to include an AQMP as part of its Integrated Development Plan.

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ABBREVIATIONS

AFIS	-	Advanced Fire Information System
APPA	-	Air Pollution Prevention Act (Act No.45 of 1965)
AQA	-	National Environmental Management: Air Quality Act (Act No. 39 of 2004)
AQMP	-	Air Quality Management Plan
ARC		Agricultural Research Council
C_6H_6	-	Benzene
CAPCO	-	Chief Air Pollution Control Officer
CH_4	-	Methane
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
CSIR	-	Centre for Scientific and Industrial Research
DEA	-	Department of Environmental Affairs
DJF	-	December, January, February
DMA	-	District Management Area
DME	-	Department of Minerals and Energy
DWAF	-	Department of Water Affairs
FPM	-	Fine Particulate Matter
GIS	-	Geographical Information Systems
GGP	-	Gross Geographic Product
H_2O	-	Water
IDP	-	Integrated Development Plan
JJA	-	June, July, August
MAM	-	March, April, May
MHS		Municipal Health Services
MODIS	-	Moderate Resolution Imaging Spectroradiometer
NASA	-	National Aeronautics and Space Administration
NGO	-	Non-Governmental Organisation
NH_3	-	Ammonia
NO	-	Nitrous oxide
NO_2	-	Nitrogen dioxide
NO_x	-	Oxides of nitrogen
O_3	-	Ozone
Pb	-	Lead
PM10	-	Particulate matter with an aerodynamic diameter of less than 10 µm
PM2.5	-	Particulate matter with an aerodynamic diameter of less than 2.5 µm
PPB	-	Parts per billion
PPM	-	Parts per million
SANS	-	South African National Standards

SANAS	-	South African National Accreditation Services
SAWS	-	South African Weather Service
SON	-	September, October, November
SO_2	-	Sulphur dioxide
SO_x	-	Oxides of sulphur
$\mu g/m^3$	-	Micrograms per cubic meter
USEPA	-	United States Environmental Protection Agency
VEP	-	Vehicle Emissions Project
VOC	-	Volatile Organic Compounds
WCDM	-	West Coast District Municipality
WHO	-	World Health Organisation

1. VISION, MISSION AND OBJECTIVES

The vision, mission, goals and objectives developed for the West Coast District Municipalities reflects the vision, mission and general approach for air quality management at the National, Provincial and Local levels. The National Framework for Air Quality Management was reviewed during this process to ensure the District is in line with National requirements.

1.1 Vision

Attainment and maintenance of good air quality for the benefit of all inhabitants and natural environmental ecosystems within the West Coast District Municipality

1.2 Mission

- To ensure the maintenance of good air quality through proactive and effective management principles that take into account the need for sustainable development into the future.
- To work in partnership with communities and stakeholders to ensure the air is healthy to breathe and is not detrimental to the well-being of persons in the District.
- To ensure that future developments (transportation, housing, etc.) incorporate strategies to minimise air quality impacts.
- To reduce the potential for damage to sensitive natural environmental systems from air pollution, both in the short and long-term.
- To facilitate intergovernmental communication at the Local, Provincial and National levels in order to ensure effective air quality management and control in the WCDM.

1.3 Commitment

- Establishing an air quality monitoring and management system in identified ‘hotspot’ areas within the District.
- Integrating air quality considerations into the town planning mechanisms especially when considering housing, transportation and spatial planning developments.

- Raising awareness around air quality issues, thereby promoting community well-being and empowerment.
- Facilitating effective inter-departmental and inter-governmental cooperation to improve air quality management and control in the District.
- Establishing a dedicated air quality department within the District to fulfill its air quality obligations and responsibilities through the appointment of dedicated air quality personnel and provide the necessary training.

1.4 Strategic Goals and Objectives

- Implementing the Air Quality Management Plan within the District.
- Assigning clear responsibilities and functions for air quality management at both District and Local levels.
- Air quality training of current and future air quality personnel at both District and Local levels.
- Obtaining the necessary resources and funding for air quality management in the District.
- Preliminary monitoring of identified ‘hotspot’ areas in the District to determine air pollutant concentrations.
- Undertaking continuous ambient air quality monitoring to obtain a long-term record of air quality in the District. Such information must be made available to the public and private sectors.
- Maintaining good air quality within the boundaries of the West Coast District, with specific emphasis on PM_{10} and SO_2 concentrations in the District.
- Compliance monitoring and enforcement air quality legislation, policies and regulations in the District.
- Assessing the contribution of agriculture to ambient air quality and establishing measures to control emissions from these sources.

2. INTRODUCTION

The National Environmental Management: Air Quality Act 39 of 2004 (AQA) requires Municipalities to introduce Air Quality Management Plans (AQMP) that set out what will be done to achieve the prescribed air quality standards. Municipalities are required to include an AQMP as part of its Integrated Development Plan.

The West Coast District Municipality is located in the Western Cape Province in South Africa. The West Coast is comprised of five Local Municipalities, namely, Bergrivier, Cederberg, Matzikama, Saldanha Bay and Swartland, as well as three District Management Areas. The District as a whole is mainly comprised of agricultural activities including wheat and potato fields, vineyards, and fruit orchards. The unique flora and picturesque landscape of this area encourage tourism in the District, while local industries include mining and fishing as well as metal processing and fishmeal production.

The main objective of the project is to develop an Air Quality Management Plan for the West Coast District Municipality, as per the requirements of the Air Quality Act of 2004.

The main objective of the West Coast District Air Quality Management Plan is *to promote clean air and to protect human health and the environment.*

In order to meet this objective, the immediate goals are: -

a) A Status Quo Assessment to determine pollution sources, ambient concentrations and the potential for human health problems in the West Coast District;

b) A Gap Analysis and Needs Assessment in order to determine the requirements relating to equipment, human resources, training and financial inputs;

c) An Air Quality Management Plan for the West Coast District;

d) An air quality By-law for the West Coast District.

2.1 Geographic Overview

The West Coast District Municipality covers an area of approximately 31 101 km^2. The Local Municipalities of Matzikama, Cederberg, Bergrivier, Saldanha Bay and Swartland fall within the District (Figure 1). The area also has 3 District Management Areas (DMAs). The 3 DMAs consist of the Cederberg Wilderness Area, the West Coast National Park and an isolated area of low population situated in the Hardeveld region to the North.

Figure 1: Local Municipalities of the West Coast District Municipality.

The most prominent economic activities in the West Coast District are agriculture, metal processing, fishmeal production and tourism. Agricultural activities focus on the production of wheat, potatoes, rooibos tea and deciduous fruit. Mineral sands mining for titanium production, steel production, fish species procurement and processing are the main industries operating in the area. Tourists are drawn to the West Coast region by its unique biodiversity, geomorphology and history, as well as the prosperous wine trade.

Based on the 2001 Census, the West Coast District has a total population of approximately 282 672 (Table 1). The more recent Community Survey in 2007 shows a 2% population growth rate in the District, with a total population of approximately 286,751. Saldanha Bay Local Municipality, which includes the towns of Vredenburg, Saldanha, Matzikama and Bergrivier Local Municipalities each have 16% of the District population and although Cederberg is the largest in terms of area (7347km^2) it has the lowest population percentage of all the Local Municipalities (11%). As expected, the smallest population group (2%) is found in the District Management Areas. The spatial distribution of the West Coast's population is depicted in Figure 2.

Table 1: **Population per Local Municipality in the West Coast District Municipality (Stats SA, 2008).**

Local Municipality	Census 2001	Community Survey 2007
Matzikama	50 208	46 362
Cederberg	39 326	31 942
Bergrivier	46 325	44741
Saldanha Bay	70 440	78 982
Swartland	72 115	77 524
DMAs	4 258	7 199
Total	**282 672**	**286 751**

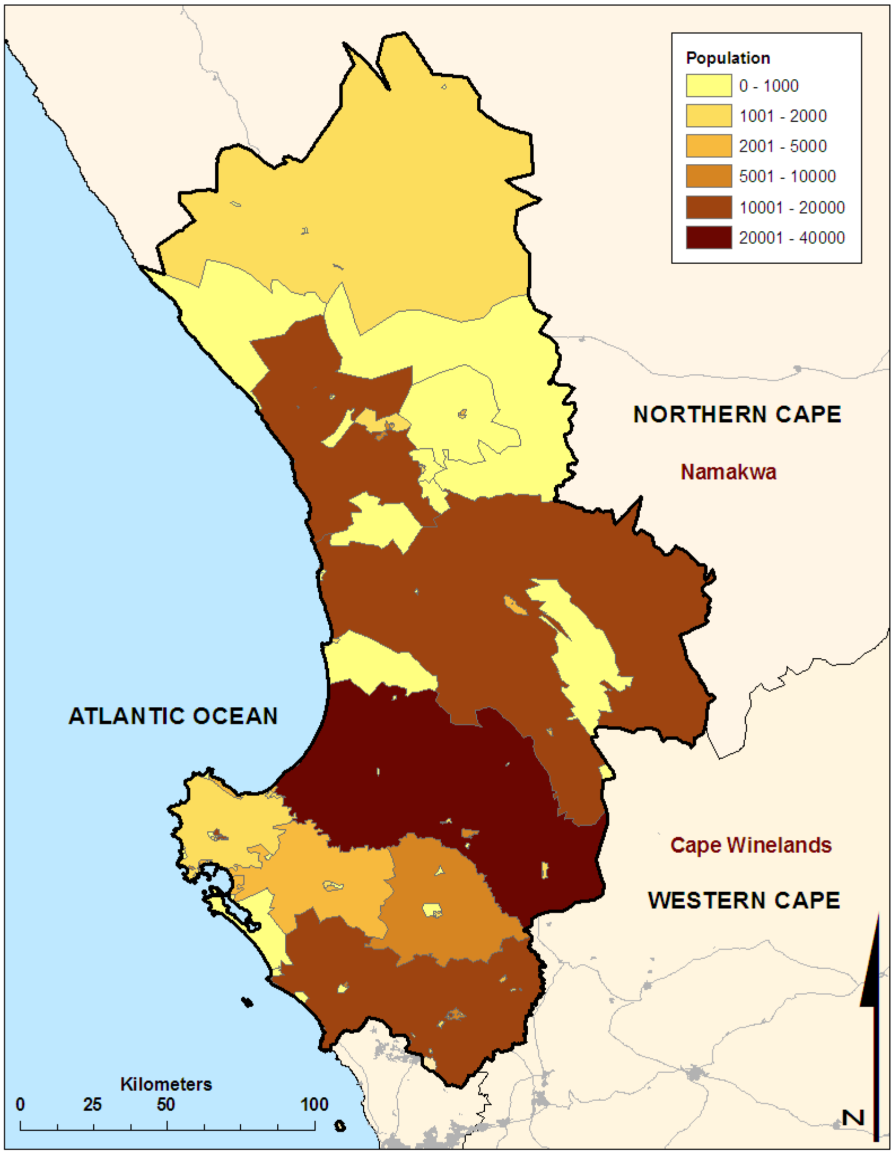


Figure 2: Population density of the West Coast District Municipality (Census 2001).

The West Coast District is characterised by varying topography (Figure 3). The landscape is fairly flat to the north, and along the coastline to the west, favouring agricultural activities. A significant part of the District is also covered in mountainous terrain running along the eastern border of the region. Geologically, this mountain range is part of the Cape Fold Belt and consists of mainly Table Mountain sandstone. The Cederberg Wilderness Area, that used to be a DMA near Clanwilliam, falls within the catchment area of the cape fynbos region and is managed as a valuable water source for the area.

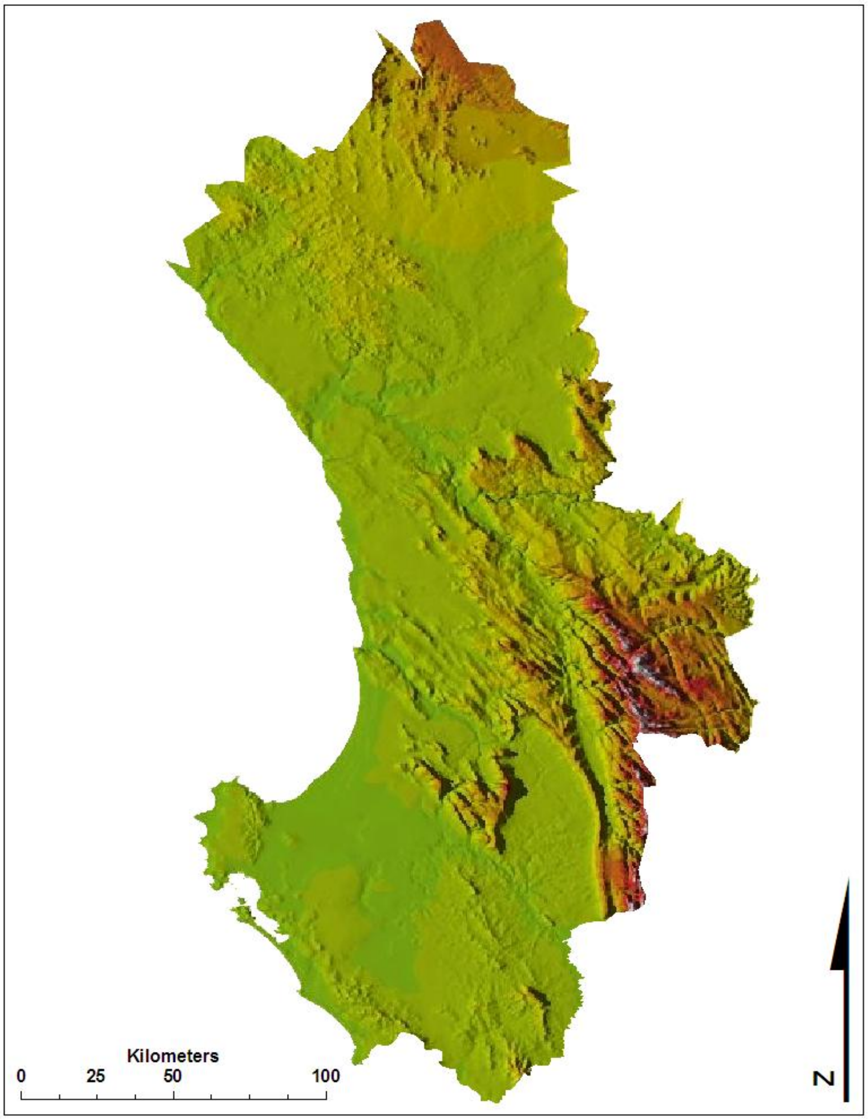


Figure 3: Topography of the West Coast District Municipality.

2.2 Methodological Approach for the development of an Air Quality Management Plan for the West Coast

The development of an Air Quality Management Plan for the West Coast District Municipality will be undertaken in a phased approach. The first phase also known as the Status Quo Assessment includes a detailed literature review, baseline characterisation, and compilation of an emissions inventory as well as dispersion modelling of criteria pollutants. The second phase consists of a gap analysis and needs assessment to evaluate municipal capacity while phase three develops the Air Quality Management

Plan based on the findings from the first two phases. As part of the Air Quality Management Plan an air pollution By-law was developed for implementation within the District.

2.2.1 Status Quo Assessment

- ***Literature Review*** – this phase includes a detailed review of local and international legislation with particular emphasis on the new Air Quality Act, No 39 of 2004. The national air quality standards were reviewed as well as applicable international guidelines and standards. Health impacts associated with criteria pollutants have also been discussed in detail. The Western Cape Provincial Government Air Quality Management Plan Guideline, DEA's Draft Air Quality Management Planning Manual and the Western Cape Climate Change Strategy and Action Plan have also been included in this review.

- ***Baseline Characterisation*** **–** this phase includes the assessment of the ambient air quality and prevailing meteorological conditions within the District. Meteorological data was obtained from the South African Weather Service (SAWS) and Agricultural Research Council (ARC) which was analysed and used as input for the dispersion model. Meteorological conditions are well monitored in the region with meteorological data selected from eight stations distributed across the district to reduce redundancy (Figure 17). Air quality monitoring data was collected from government and industry. Data was received from the Vredenburg Monitoring Station, Blue Water Bay, ArcelorMittal and Port of Saldanha monitoring stations.

- ***Emissions Inventory*** **–** this phase of the assessment includes the compilation of an emissions inventory with specific focus on quantifiable sources such as industries, vehicles and domestic fuel burning. This information will form the framework of an emissions inventory database which will be updated during the implementation phase of the AQMP. The emissions inventory for the WCDM has been compiled through a review of previous studies done in the area, availability of existing emissions databases as well as questionnaires and site visits. Where data could not be collected through these methods (i.e.: informal settlements,

waste disposal and traffic) emissions were quantified by means of emission factors and internationally accepted methodologies. Industries in the district were contacted for information on their fuel burning appliances. For sources such as vehicles and domestic fuel burning, use was made of international and local emission factors to estimate emissions. Fuel sales per magisterial district were obtained from the Department of Minerals and Energy, while vehicle fleet data was provided by the District Municipality. For domestic fuel burning, household fuel usage was obtained from the Census 2001 database. Other sources such as agriculture, biomass burning and waste disposal sites are discussed but not quantified due to the availability of accurate and current information.

- ***Dispersion Modelling*** – major sources of pollution identified by the emissions inventory were grouped into class, significance and associated impact. This information was fed into a dispersion model. Simulations will be run to determine the pattern of impact of criteria pollutants from these sources, as well as their compliance with the national standards.
  Dispersion modelling simulations was undertaken using the international ADMS 4 model developed by the Cambridge Environmental Research Consultants in the United Kingdom. Dispersion modelling predictions together with the monitored data were used to determine compliance with the National Ambient Air Quality Standards.

2.2.2 Gap Analysis and Needs Assessment

The Gap Analysis and Needs Assessment evaluates the current capacity of Government (Local, District and Provincial) for air quality management and control in terms of personnel, skills, resources and tools. Questionnaires were developed and sent out to each of the five Local Municipalities, the West Coast District Municipality and the Western Cape Province to obtain information on their organisational structures, air quality functions and available hardware and software for air quality management and control.

2.2.3 Air Quality Management Plan

The development of the Air Quality Management Plan incorporated the findings from the Status Quo Assessment and the Gap Analysis and Needs Assessment. An overview of National air quality legislation as well as legislation influencing Local Government is provided. Key pollutants and areas of concern are identified in the District based on the ambient air quality monitoring data and the dispersion modelling predictions. Emission reduction strategies are proposed for the major source contributors with achievable timeframes associated with each intervention. Recommendations for the implementation of an air quality monitoring programme in the District were also be made.

2.2.4 Air Quality By-Law

An air quality By-law will be developed for the District as part of the Air Quality Management Plan. The generic By-law developed by DEA will be reviewed and stakeholder participation will be taken into account throughout the development of the By-law. (A draft By-Law for the WCDM has been compiled).

2.2.5 Stakeholder Engagement

On-going throughout the development of the Air Quality Management Plan is stakeholder engagement. Stakeholder engagement is critical to the success of the Plan. So far key stakeholders have been identified while public participation meetings will take place later in the development of the AQMP. (Public participation meetings were held in all five Local Municipal areas)

2.3 Local Air Quality Management Plans

The Air Quality Act aims to provide reasonable measures to prevent air pollution and give effect to Section 24 of the Constitution. The Air Quality Act states that local authorities are required to develop AQMPs as part of their Integrated Development Plans. Within South Africa, various Municipalities have addressed their responsibilities and developed AQMPs, including Rustenburg Local Municipality (2005), Capricorn District Municipality (2006), Eden District Municipality (2008), City of Johannesburg Metropolitan Municipality (2003), Ekurhuleni Metropolitan Municipality (2004), City of Cape Town Metropolitan Municipality (2006), City of Tshwane Metropolitan Municipality

(2006), eThekwini Metropolitan Municipality (2007), Cape Winelands District Municipality (2008) and Waterberg District Municipality (2009).

The Air Quality Act also makes provision for the identification of priority areas where the air quality is regarded as poor and detrimental to human health and the environment. Priority Area designation has been introduced as part of Air Quality Management in South Africa to direct limited resources into areas requiring urgent attention. The Vaal Triangle was declared the first priority area in South Africa by the Minister of Environmental Affairs on the 21st of April 2006. Once declared, a Priority Area Air Quality Management Plan must be developed within 6 months after declaration. The Priority Area Air Quality Management Plan is a specific tool to plan resources and interventions and is developed cooperatively with authorities, industries, and communities. The Vaal Triangle Airshed Priority Area Air Quality Management Plan was the first Air Quality Management Plan to be developed for a priority area in South Africa. The Highveld is the second area to be declared a priority area, the Air Quality Management Plan for which is still being developed.

The AQMP for the West Coast District will be in line with the AQMPs developed locally. The guidelines outlined in the *Air Quality Management Plan Guideline* document developed by the Western Cape Provincial Government and the *National Framework for Air Quality Management in the Republic of South Africa* and the *AQMP guideline document from National Government* will also be followed.

2.4 Outline of Report

Section 3 describes the policy and legislative requirements with specific reference to air quality legislation and the National air quality standards. **Section 4** gives an overview of the criteria pollutants and associated health and environmental impacts. **Section 5** provides an overview of the prevailing meteorological conditions in the District. The development of an emissions inventory is presented in **Section 6** along with dispersion model simulations. **Section 7** describes the current air quality practices and initiatives within provincial and local government. **Section 8** describes capacity building within local government. **Section 9** describes Implementation of air quality management plan and **section 10** gives conclusions and the way forward.

3. POLICY AND REGULATORY REQUIREMENTS

3.1 Air Pollution Prevention Act 45 of 1965

The Atmospheric Pollution Prevention Act 45 of 1965 (APPA) focuses mainly on source based control with registration certificates issued for Scheduled Processes. Scheduled Processes are defined as processes which emit more than a defined quantity of pollutants per year. This legislation made provision for the control of noxious or offensive gases from Scheduled Processes which are subject to the Best Practicable Means (BPM) of pollution abatement. BPM is a set of guidelines issued by the Department of Environmental Affairs (DEA) stipulating the level of technology that is the best practicable means of preventing or reducing to a minimum the escape of noxious or offensive gases into the atmosphere at source. The Chief Air Pollution Control Officer (CAPCO) of DEA was responsible for the implementation of the BPM approach. Control of smoke emissions was enforced by local authorities through regulation and smoke control zones. Dust emissions from mining and quarrying activities were also controlled and enforced by the CAPCO as well as by the Department of Minerals and Energy through the inspection of mines. Provision was also made for the control of vehicle exhaust emissions. However, APPA is out dated and has been replaced with the Air Quality Act 39 of 2004 (AQA) which came into effect on 11 September 2005 and has been in full effect since 1 April 2010. The licensing of industrial activities has now become the responsibility of local authorities or metropolitan municipalities for larger cities. Should local authorities be unable to fulfil licensing functions it becomes the responsibility of the provincial authorities. Capacity and skills development of local officials to undertake the licensing function is a key factor instrumental to the success of this approach.

3.2 National Environmental Management: Air Quality Act 39 of 2004

The National Environmental Management: Air Quality Act 39 of 2004 has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to:

- Give effect to everyone’s right “to an environment that is not harmful to their health and well-being”,
- Protect the environment by providing reasonable legislative and other measures that (i) prevent pollution and ecological degradation, (ii) promote conservation

and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The Act makes provision for the setting and formulation of national ambient air quality standards for *"substances or mixtures of substances which present a threat to health, well-being or the environment"*. More stringent standards can be established at the provincial and local levels through the development of by-laws. The control and management of emissions in AQA relates to the listing of activities that are sources of emissions and the issuing of emission licences. Listed activities are defined as activities which *"result in atmospheric emissions and are regarded to have a significant detrimental effect on the environment, including human health"* and have been identified by the minister of DEA. Atmospheric emission standards have been established for each of these activities and an atmospheric emission licence is required to operate. The issuing of emission licences for Listed Activities is the responsibility of the metropolitan and district municipalities. In addition, the minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to *"designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality"*. The appointed Air Quality Officer will be responsible for the issuing of atmospheric emission licences.

The Act also introduces the compulsory monitoring of ambient air quality. The national framework, which is currently under review, will legislate protocols, standards and methodologies for monitoring. The Act also requires relevant national departments, provinces and municipalities to introduce Air Quality Management Plans (AQMPs) that set out what will be done to achieve the prescribed air quality standards. Metropolitan, District and Local Municipalities are required to include an AQMP as part of its Integrated Development Plan.

A summary of the functions and responsibilities of National, Provincial and Local Government, as informed by the new Air Quality Act and the National Framework for Air Quality Management in the Republic of South Africa, are given in Table 2.

Table 2: Air quality responsibilities and functions of National, Provincial and Local Government.

National Government	Provincial Government	Local Government
Establish and review National Framework	None	None
Identify National priority pollutants	Identify Provincial priority pollutants	Identify priority pollutants (in terms of its by-laws)
Establish National air quality standards	Establish Provincial air quality standards	Establish Local air quality standards (more stringent)
Establish National emission standards	Establish Provincial emission standards	Establish Local emission standards
Appoint National Air Quality Officer	Appoint Provincial Air Quality Officer	Appoint Local Air Quality Officer
Prepare a National AQMP as a component of their EIP	Prepare a Provincial AQMP as a component of their EIP	Develop an AQMP as part of their IDPs
Execute overarching auditing function to ensure that adequate air quality monitoring occurs	Ambient air quality monitoring	Ambient air quality monitoring
Declare National priority areas	Declare Provincial priority areas	None
Prepare National priority areas AQMP	Prepare Provincial priority areas AQMP	None
Prepare an annual report regarding the implementation of the AQMP	Prepare an annual report regarding the implementation of the AQMP	Prepare an annual report regarding the implementation of the AQMP
Prescribe regulations for implementing and enforcing the priority area AQMP	Prescribe regulations for implementing and enforcing the priority area AQMP	None
List activities	List activities	None
None	Perform emission licensing authority functions	Perform emission licensing authority functions
Declare controlled emitters	Declare controlled emitters	None
Declare and set requirements for controlled fuels	Declare and set requirements for controlled fuels	None
Set requirements for pollution prevention plans	Establish a programme of public recognition of significant achievement in air pollution prevention	None
Prescribe measures for the control of dust, noise and odours	Prescribe measures for the control of dust, noise and odours	None

National Government	Provincial Government	Local Government
Investigate and regulate trans boundary pollution	None	None
Investigate potential international agreement contraventions	None	None

3.3 Legislation for Local Government

The Local Government: Municipal Systems Act 32 of 2000, together with the Municipal Structures Act 117 of 1998, establishes local government as an autonomous sphere of government with specific powers and functions as defined by the Constitution. Section 155 of the Constitution provides for the establishment of Category A, B and C Municipalities each having different levels of municipal executive and legislative authorities. According to Section 156(1) of the Constitution, a municipality has the executive authority in respect of, and has the right to, administer the local government matters (listed in Part B of Schedule 4 and Part B of Schedule 5) that deal with air pollution. Section 156(2) makes provision for a municipality to make and administer By-laws for the effective administration of any matters which it has the right to administer as long as it does not conflict with national or provincial legislation. The Municipal Systems Act as read with the Municipal Financial Management Act requires municipalities to budget for and provide proper atmospheric environmental services. In terms of the National Health Act 61 of 2003, municipalities are expected to appoint a health officer who is required to investigate any state of affairs that may lead to a contravention of Section 24(a) of the Constitution. Section 42(a) states that each person has the right to an environment that is not harmful to their health or well-being.

Furthermore the Municipal Structures Act 117 of 1998 provides that a municipality has the powers and functions assigned to it in terms of sections 156 and 229 of the Constitution. Such powers must be divided between a district municipality and the local municipalities falling within its area. It also states, as the Constitution states in sections 156 and 229, that municipalities (local and district) have the powers and function to provide and seek to achieve the integrated, sustainable and equitable social and economic development of its area as a whole.

The Municipal Structures Act also states in section 83 that district municipalities are responsible for capacity building of local municipalities in its area to perform their

functions and exercise their powers where such capacity is lacking; and promoting the equitable distribution of resources between the local municipalities in its area to ensure appropriate levels of municipal services within the area. This Act also states that, according to the Constitution that air pollution is an exclusive Local Government competence but the Municipal Structures Act provides that one of a district municipality's powers and functions is integrated development planning for its area as a whole. A district municipality shall further include a framework for integrated development plans (IDPs) of all municipalities in its area. This means that Air Pollution is the responsibility of both local and district municipalities.

The Promotion of Access to Information Act 2 of 2000, in conjunction with Section 32 of the Constitution, entitles everyone to the right of access to any information held by government and private individuals. The relevance of the right to information is that government, industry and private individuals can be compelled, through court proceedings if required, to make information available regarding the state of the atmosphere and pollution. The Promotion of Administrative Justice Act 3 of 2000 which was introduced by the State to give effect to Section 33 of the Constitution provides everyone with the right to administrative action that is lawful, reasonable and procedurally fair and the right to be given written reasons when rights have been adversely affected by administrative action.

3.4 Local Air Quality By-Laws

Section 156(2) of the Constitution of the Republic of South Africa makes provision for a Local Municipality to make and administer By-laws for the effective administration of the matters which it has the right to administer so long as such By-laws do not conflict with National or Provincial legislation.

Within the West Coast District, no air quality By-laws have been implemented at either the District or Local levels. The Department of Environmental Affairs has developed a generic air pollution control By-law for Municipalities. An air quality By-law for the West Coast District has been modelled on these draft By-laws.

The City of Cape Town is the first Municipality in South Africa to establish an air pollution control By-law with the objective of *"ensuring that air pollution is avoided, or where it cannot be altogether avoided, is minimised and remedied".* Any person who is

responsible for causing significant air pollution or creating a risk of significant air pollution occurring, must take reasonable measures to prevent any potential significant air pollution from occurring and mitigate any significant air pollution that has occurred.

The City of Cape Town is declared as an air pollution control zone within which the Council may:

(a) prohibit or restrict the emission of one or more pollutants from all premises or certain premises;
(b) prohibit or restrict the combustion of certain types of fuel;
(c) declare smokeless zones,
(d) prescribe different requirements in an air pollution control zone relating to air quality control in respect of different geographical portions, specified premises, and classes of premises or premises used for specific purposes.

The By-law also places stringent controls on smoke emissions from fuel burning appliances and dwellings within the City of Cape Town. Provision is also made for the control of smoke emissions from vehicles.

3.5 Ambient Air Quality Guidelines and Standards

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and well-being (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. Air quality guidelines and standards can be developed for the following averaging periods, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average and annual average.

The South African Bureau of Standards (SABS), in collaboration with DEA, established ambient air quality standards for criteria pollutants. Two standards were published as part of this process:

- SANS 69:2004 - Framework for setting and implementing national ambient air quality standards
- SANS 1929:2005 - Ambient Air Quality - Limits for common pollutants

SANS 69 defines the basic principles of a strategy for air quality management in South Africa. This standard supports the establishment and implementation of ambient air quality objectives for the protection of human health and the environment. Such air quality objectives include:

- *Limit values* - to be based on scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and the environment as a whole. Limit values are to be attained within a given period and are not to be exceeded once attained.
- *Target values* - to be set to avoid harmful long-term effects on human health and the environment. Target values represent long-term goals to be pursued through cost-effective progressive methods. At these values, pollutants are either harmless or unlikely to be reduced through expending further reasonable cost on abatement due to background sources or other factors.
- *Alert thresholds* - refer to levels beyond which there is a risk to human health from brief exposure. The exceedance of such thresholds necessitates immediate steps.

The SANS 1929 standard sets limit values based on human health effects of SO_2, PM10, NO_x, O_3, lead and benzene concentrations.

3.5.1 National Ambient Air Quality Standards

The Department of Environmental Affairs issued ambient air quality guidelines for several criteria pollutants, including particulates, sulphur dioxide, oxides of nitrogen, lead, ozone and carbon monoxide on. The Air Quality Act of 2004 adopted these guidelines as National ambient air quality standards. On 2 June 2006, the Minister of Environmental Affairs announced his intention of setting new ambient air quality standards in terms of Section 9(1)(a) and (b) of the Air Quality Act. The proposed new standards were published for public comment in the Government Gazette of 9 June 2006. Since then, updated draft National standards with allowable frequencies of exceedance and compliance timeframes were proposed. The National Ambient Air Quality Standards were approved and published in the Government Gazette on 24 December 2009 (Gazette No. 33041, Notice No.1210) and are shown in Table 3.

Table 3: South African National standards (µg/m³) for criteria pollutants with allowable frequencies of exceedance shown in brackets. The values indicated in blue are expressed in ppb.

Pollutant	Averaging Period	Immediate	2012	2017	2022
Sulphur dioxide SO_2	10-minute running average	500 (526) (191)	500 (263) (191)	500 (50) (191)	
	1-hr average	350 (88) (134)	350 (44) (134)	350 (9) (134)	
	24-hr average	125 (4) (48)	125 (2) (48)	125 (1) (48)	
	Annual average	50 (0) (19)			
Nitrogen dioxide NO_2	1-hr average	200 (88) (106)			
	Annual average	100 (0) (53)	70 (0) (37)	55 (0) (29)	40 (0) (21)
Carbon monoxide CO	1-hr average	30 000 (88) (26 000)			
	8-hourly running average	10 000 (11) (8 700)			
Ozone O_3	8-hourly running average	120 (11) (61)			
Particulate Matter PM10	24-hr average	75 (4)			
	Annual average	40 (0)			
Lead Pb	Annual average	0.5 (0)			
Benzene C_6H_6	Annual average	5 (0) (1.6)			

4. CRITERIA POLLUTANTS AND ASSOCIATED HEALTH AND ENVIRONMENTAL IMPACTS

Deteriorating urban air quality has implications for human health, climate and visibility. An overview of the criteria pollutants and associated human health and environmental impacts is discussed in the section below.

4.1 Human Health Impacts

4.1.1 Particulate Matter

Particles can be classified by their aerodynamic properties into coarse particles, PM10 (particulate matter with an aerodynamic diameter of less than 10 μm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 μm) (Harrison and van Grieken, 1998). The fine particles contain the secondarily formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dust from roads and industries (Fenger, 2002).

In terms of health impacts, particulate air pollution is associated with effects of the respiratory system (WHO, 2000). Particle size is important for health, because it controls where in the respiratory system a given particle deposits. Fine particles have been found to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

Short-term exposure

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 $\mu g/m^3$). Morbidity associated with short-term exposure to particulates includes increases in lower respiratory symptoms, medication use and small reductions in lung function.

Long-term exposure

Long-term exposure to low concentrations (~10 $\mu g/m^3$) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children.

4.1.2 Sulphur dioxide

SO_2 originates from the combustion of sulphur-containing fuels and is a major air pollutant in many parts of the world. Health effects associated with exposure to SO_2 are also associated with the respiratory system. Being soluble, SO_2 is readily absorbed in the mucous membranes of the nose and upper respiratory tract (Maroni *et al*., 1995).

Short-term exposure

Most information on the acute effects of SO_2 is derived from short-term exposure in controlled chamber experiments. These experiments have demonstrated a wide range of sensitivity amongst individuals. Acute exposure of SO_2 concentrations can lead to severe bronchoconstriction in some individuals, while others remain completely unaffected. Response to SO_2 inhalation is rapid with the maximum effect experienced within a few minutes. Continued exposure does not increase the response. Effects of SO_2 exposure are short-lived with lung function returning to normal within a few minutes to hours (WHO, 2000).

Exposure over 24 hours

The effects of exposure to SO_2, averaged over a 24 hour period, are derived from epidemiological studies in which the effects of SO_2, particulates and other associated pollutants are assessed. Studies of the health impact of emissions from the inefficient burning of coal in domestic appliances have shown that when SO_2 concentrations exceed 250 $\mu g/m^3$ in the presence of particulate matter (as sulphates), an exacerbation of symptoms is observed in selected sensitive patients. More recent studies of health impacts in ambient air polluted by industrial and vehicular activities have demonstrated at low levels effects on mortality (total, cardiovascular and respiratory) and increases in hospital admissions. In these studies, no obvious SO_2 threshold level was identified (WHO, 2000).

Long-term exposure

Long-term exposure to SO_2 has been found to be associated with an exacerbation of respiratory symptoms and a small reduction in lung function in children in some cases. In adults, respiratory symptoms such as wheezing and coughing are increased.

4.1.3 Nitrogen dioxide

Nitric oxide (NO) is a primary pollutant emitted from the combustion of stationary sources (heating, power generation) and from motor vehicles. Nitrogen dioxide (NO_2) is formed through the oxidation of nitric oxide. Oxidation of NO by O_3 occurs rapidly, even at low levels of reactants present in the atmosphere. Altshuller (1956) calculated that 50% conversion of nitric oxide would take less than 1 minute at a NO concentration of 120 µg/m^3 (0.1 ppm) in the presence of an O_3 concentration of 200 µg/m^3 (0.1 ppm). As a result, this reaction is regarded as the most important route for nitrogen dioxide production in the atmosphere.

Nitrogen dioxide is an important gas, not only because of its health effects, but because it (a) absorbs visible solar radiation and contributes to visibility impairment, (b) could have a potential role in global climate change if concentrations were to increase significantly, (c) is a chief regulator of the oxidizing capacity of the free troposphere by controlling the build-up and fate of radical species, including hydroxyl radicals and (d) plays a critical role in determining ozone concentrations.

Short-term exposure

At concentrations greater than 1880 µg/m^3 (1000 ppb), changes in the pulmonary function of adults is observed. Normal healthy people exposed at rest or with light exercise for less than 2 hours to concentrations above 4700 µg/m^3 (2500 ppb), experience pronounced decreases in pulmonary function. Asthmatics are potentially the most sensitive subjects although various studies of the health effects on asthmatics have been inconclusive. The lowest concentration causing effects on pulmonary function was reported from two laboratories that exposed mild asthmatics for 30 – 110 minutes to 565 µg/m^3 (301 ppb) during intermittent exercise (WHO, 2000).

Long-term exposure

Epidemiological studies have been undertaken on the indoor use of gas cooking appliances and health effects. Studies on adults and children under 2 years of age found no association between the use of gas cooking appliances and respiratory effects. Children aged 5 – 12 years have a 20% increased risk for respiratory symptoms and disease for each increase of 28 µg/m^3 (15 ppb) NO_2 concentration, where the weekly average concentrations are in the range of 15 – 128 µg/m^3 (8 – 68 ppb) (WHO, 2000).

Outdoor studies consistently indicate that children with long-term ambient NO_2 exposures exhibit increased respiratory symptoms that are of a longer duration. However, no evidence is provided for the association of long-term exposures with health effects in adults (WHO, 2000).

4.1.4 Ozone

Ozone in the atmosphere is a secondary pollutant formed through a complex series of photochemical reactions between NO_2 and VOCs in the presence of sunlight. Sources of these precursor pollutants include motor vehicles and industries. Atmospheric background concentrations are derived from both natural and anthropogenic sources. Natural concentrations of O_3 vary with altitude and seasonal variations (i.e. summer conditions favour O_3 formation due to increased insolation). Diurnal patterns of O_3 vary according to location, depending on the balance of factors affecting its formation, transport and destruction. From the minimal levels recorded in the early morning, concentrations increase as a result of photochemical processes and peak in the afternoon. During the night, O_3 is scavenged by nitric oxide. Seasonal variations in O_3 concentrations also occur and are caused by changes in meteorological conditions and insolation. Quarterly mean (arithmetic average of daily values for a calendar quarter) O_3 concentrations are typically highest in summer (WHO, 2000).

Ozone contributes to the formation of significant amounts of organic and inorganic aerosols. Correlations between concentrations of O_3 and sulphuric acid, nitric acid, sulphates and nitrates have been observed (Grennfelt, 1984).

Ozone is a powerful oxidant and can react with a wide range of cellular components and biological materials. Health effects and the extent of the damage associated with O_3 exposure is dependent on O_3 concentrations, exposure duration, exposure pattern and ventilation (WHO, 2000).

Short-term exposure

Short-term effects include respiratory symptoms, pulmonary function changes, increased airway responsiveness and inflammation. Field studies in vulnerable persons (children, adolescents, young adults, elderly and asthmatics) have indicated that pulmonary function decrements can occur as a result of short-term exposure to O_3 concentrations in

the range 120 – 240 µg/m^3 (61 – 122 ppb) and higher. Ozone exposure has also been reported to be associated with increased hospital admissions for respiratory causes and exacerbation of asthma (WHO, 2000).

Long-term exposure

There is limited information linking long-term O_3 exposure to chronic health effects, however, there are suggestions that cumulative O_3 exposures may be linked with increasing asthma severity and the possibility of increased risk of becoming asthmatic (Abbey *et al*., 1993).

Evidence provided by studies of health effects related to chronic ambient O_3 exposure is consistent in indicating chronic effects on the lung. Some studies have shown that long-term exposure to concentrations of O_3 in the range 240 – 500 µg/m^3 (122 – 255 ppb) causes morphological changes in the region of the lung resulting in a reduction in lung function (WHO, 2000).

4.1.5 Carbon monoxide

Carbon monoxide (CO) is one of the most common and widely distributed air pollutants. CO is a tasteless, odourless and colourless gas which has a low solubility in water. In the human body, after reaching the lungs it diffuses rapidly across the alveolar and capillary membranes and binds reversibly with the haem proteins. Approximately 80 - 90% of CO binds to haemoglobin to form carboxyhaemoglobin (COHb) which is a specific biomarker of exposure in blood. The affinity of haemoglobin for CO is 200 – 250 times that for oxygen. This causes a reduction in the oxygen-carrying capacity of the blood which leads to hypoxia as the body is starved of oxygen.

Anthropogenic emissions of CO originate from the incomplete combustion of carbonaceous materials. The largest proportion of these emissions is produced from exhausts of internal combustion engines, in particular petrol vehicles. Other sources include industrial processes, coal power plants and waste incinerators. Ambient CO concentrations in urban areas depend on the density of vehicles and are influenced by topography and weather conditions. In the streets, CO concentrations vary according to the distance from the traffic. In general, the concentration is highest at the leeward side

of the ‘street canyon’ with a sharp decline in concentration from pavement to rooftop level (Rudolf, 1994).

Short and Long-term exposure

The adverse health effects of CO vary depending on the concentration and time of exposure. Clinical symptoms range from headaches, nausea and vomiting, muscular weakness, and shortness of breath at low concentrations (10 ppm) to loss of consciousness and death after prolonged exposure or after acute exposure to high CO concentrations (>500 ppm). Poisoning may cause both reversible, short-lasting neurological deficits and severe, often delayed, neurological damage. Neurobehavioral effects include impaired co-ordination, tracking, driving ability, vigilance and cognitive ability at COHb levels as low as 1.5 - 8.2% (WHO, 2000).

High risk patients with regards to CO exposure include persons with cardiovascular diseases (especially ischaemic heart disease), pregnant women, foetuses and new-born infants. Epidemiological and clinical studies indicate that CO from smoking and environmental or occupational exposures may contribute to cardiovascular mortality (WHO, 2000).

4.1.6 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are organic chemicals that easily vapourise at room temperature and are colourless. VOCs are released through vehicle exhaust gases either as unburned fuels or as combustion products, and are also emitted by the evaporation of solvents and motor fuels. Short-term exposure to VOCs can cause eye and respiratory tract irritation and damage, headaches, dizziness, visual disorders, fatigue, loss of coordination, allergic skin reactions, nausea, memory impairment, damage to the bone marrow and even death. Long-term exposure to high levels of VOCs has been linked to an increase in occurrence of leukaemia. VOCs can also cause damage to the liver, kidneys and central nervous system.

4.1.6.1 Benzene

Benzene in air exists predominantly in the vapour phase, with residence times varying between a few hours and a few days, depending on the environment, climate and the

concentration of other pollutants. The only benzene reaction, which is important in the lower atmosphere, is the reaction with hydroxy radicals. The products of this reaction are phenols and aldehydes, which react quickly and are removed from air by rain.

Benzene is a natural component of crude oil, and petrol contains 1 – 5% by volume. Benzene is produced in large quantities from petroleum sources and is used in the chemical synthesis of ethyl benzene, phenol, cyclohexane and other substituted aromatic hydrocarbons. Benzene is emitted from industrial sources as well as from combustion sources such as motor engines, wood combustion and stationary fossil fuel combustion. The major source is exhaust emissions and evaporation losses from motor vehicles, and evaporation losses during the handling, distribution and storage of petrol.

Information on health effects from short-term exposure to benzene is fairly limited. The most significant adverse effects from prolonged exposure to benzene are haematotoxicity, genotoxicity and carcinogenicity. Chronic benzene exposure can result in bone marrow depression expressed as leukopenia, anaemia and/or thrombocytopenia, leading to pancytopenia and aplastic anaemia. Based on this evidence, C_6H_6 is recognized to be a human and animal carcinogen. An increased mortality from leukaemia has been demonstrated in workers occupationally exposed (WHO, 2000).

4.1.6.2 Toluene

Toluene is produced from the catalytic conversion of petroleum and aromatization of aliphatic hydrocarbons and as a by-product of the coke oven industry. The bulk of production is in the form of a benzene-toluene-xylene mixture that is used in the back blending of petrol to enhance octane ratings. Toluene is used as a solvent, carrier or thinner in the paint, rubber, printing, cosmetic, adhesives and resin industries, as a starting material for the synthesis of other chemicals and as a constituent of fuels (WHO, 2000).

Toluene is believed to be the most prevalent hydrocarbon in the atmosphere. Reactions with hydroxy radicals are the main mechanisms by which toluene are removed from the atmosphere. The lifetime of toluene can range from a few days in summer to a few months in winter (WHO, 2000).

The short-term and long-term effects of toluene on the central nervous system are of great concern. Toluene may also cause developmental decrements and congenital abnormalities in humans. The potential effects of toluene exposure on reproduction and hormonal imbalances in women are also of concern. Men occupationally exposed to toluene at 5 – 25 ppm have also been shown to exhibit hormonal imbalances. Limited information suggests an association between occupational toluene exposure and spontaneous abortions at an average concentration 88 ppm. Toluene has minimal effects on the liver and kidney, except in cases of toluene abuse. Studies have not indicated that toluene is carcinogenic (WHO, 2000).

4.2 Environmental Impacts

Trace gases and aerosols impact climate through their effect on the radiative balance of the earth. Trace gases such as greenhouse gases absorb and emit infrared radiation which raises the temperature of the earth's surface causing the enhanced greenhouse effect. Aerosol particles have a direct effect by scattering and absorbing solar radiation and an indirect effect by acting as cloud condensation nuclei. Atmospheric aerosol particles range from dust and smoke to mists, smog and haze (IPCC, 2001). Smog and haze are common in regions where certain geographic features, such as mountains, and weather conditions, such as temperature inversions, contribute to the trapping of air pollutants (Kumar and Mohan, 2002). Smog and haze also contribute to visibility degradation through the absorption and scattering of radiation by gases and particulates (Elsom, 1996). This smog or 'brown haze' can be observed in Cape Town during the winter months (April to September) when strong temperature inversions and calm conditions promote the stagnation of pollutants. The haze extends over most of the City of Cape Town and shifts according to the prevailing wind direction.

Other environmental impacts associated with air pollution include loss of biodiversity, damage to sensitive environments and acid rain. Acid rain is a general term referring to a combination of wet and dry deposition from the atmosphere containing elevated amounts of sulphuric and nitric acid. Acid rain occurs when SO_2 and NO_x are emitted into the atmosphere, undergo chemical transformation and are absorbed by water droplets in clouds. The droplets then fall to earth as rain, snow, mist, dust, hail or sleet. This increases the acidity of soil and affects the chemical balance of dams and rivers. Acid rain can also cause damage to buildings and infrastructure.

4.2.1 Western Cape Climate Change Response and Action Strategy

Significant climate change is likely within the next 50 years, as a consequence of human-induced changes in the composition of the atmosphere. The Western Cape Province is a relatively low greenhouse gas emitter in comparison to other regions in South Africa. Of the total carbon dioxide (CO_2) produced in the Province, industry accounts for 48% of CO_2 emissions, transport accounts for 22% and residential areas account for 15% of emissions (OneWorld Sustainable Investments, 2007).

Climate change modelling simulations for the Western Cape Province have been undertaken by the Climate Science Analysis Group at the University of Cape Town. Future projections for the period 2030 – 2045 indicate that a decrease in precipitation will be experienced in the far south-west of the Province in all seasons. The decrease will be strongest in early and mid-winter. In the eastern coastal regions, there are likely to be moderate increases in the early winter, with moderate decreases in late winter. In the interior and zones to the north-east, small increases in rainfall are likely. Projections for temperature predict a minimum of 1 °C warming by the late 2030s compared to the second half of the 20th century and warmer minimum temperatures. The warming trend increases from the south-west to the north-east, with warming most pronounced in the spring and summer months (OneWorld Sustainable Investments, 2007).

In response to climate change, the Western Cape Province has developed the Western Cape Provincial Climate Change Response and Action Plan Strategy to address the potential impacts associated with climate change in the Province. The response strategy and action plan aims to strengthen the Province's resilience to climate change and its adaptive capacity and aims to maintain the Province's status as a relatively low greenhouse gas emitter by reducing the Provincial carbon footprint (OneWorld Sustainable Investments, 2007).

The Western Cape's Climate Change Action Plan is based on a set of integrated cross-sectoral planning and implementation programmes, which include both mitigation and adaption responses, and are outcome based. The following programmes are prioritised:

- *An integrated water supply and infrastructure management programme that integrates climate impacts and risks* - researching the cost benefit of irrigation, increasing water efficiency through pricing strategies, establishing uninterrupted

water conservancy targets, systems maintenance and repairs and establishing the ecological reserve,

- *Establishing clear links between land stewardship, livelihoods and the economy -* effective land use and land care; protection, maintenance and enhancement of natural resources, strengthening vulnerable communities and protecting livelihoods through targeted research, maintaining diversity in the economy, integrating climate risks into development planning,
- *Establishing a focused climate change research and weather information programme* – increase the number of air quality monitoring stations, research pest sensitivity to climate change, research irrigation efficiency, foster science/environmental/government dialogue and obtain weather stations,
- *Reducing the Provincial carbon footprint -* energy efficiency, development of renewable and alternate sustainable energy resources, effective waste management strategies and cleaner fuel programmes for households and transport.

With specific reference to air quality issues in the Western Cape, air quality can be sensitive to increased temperatures, increased greenhouse gas emissions as well as an increased demand for local fuels. Impacts associated with climate change and the failure to implement mitigation measures may result in increased air pollution episodes such as the 'brown haze'. Measures to address climate change include increasing the number of monitoring stations in the Western Cape, effectively dissemination air quality information and introducing cleaner fuel programmes for households and transport. The Province have proposed the installation of two to four more air quality monitoring stations in Cape Town and seven new stations in the rest of the Province, as well as improving the current capacity in terms of human resources and finances for air quality management and monitoring. Through the dissemination of information, air pollution episodes can be reduced and human health impacts can be minimized if early warning and response is improved. The introduction of alternate fuels such as gel fuel and LPG for domestic fuel burning purposes and the installation of ceilings in low-cost housing have also been proposed to address air pollution. The use of cleaner fuels for public transport vehicles and the proposed biofuel blending programme are recommended initiatives to reduce greenhouse gas emissions from vehicles.

5. METEOROLOGICAL OVERVIEW OF THE WEST COAST DISTRICT MUNICIPALITY

Once pollutants are emitted into the atmosphere they move away from the source and disperse. The ability of the atmosphere to disperse pollutants varies both geographically and temporally. Conditions that promote dispersion result in lower concentrations of pollution whereas those that inhibit dispersion cause pollutants to accumulate near the source, increasing pollution concentrations. Therefore knowledge of how the atmosphere behaves assists in understanding the movement of pollutants and hence in determining concentrations at particular locations. Vertical and horizontal movement of pollutants is governed by atmospheric stability and wind characteristics respectively; while chemical transformation of pollutants is dependent on solar radiation and moisture; and the removal of pollutants from the atmosphere results from precipitation. Thus air pollution meteorology forms the basis of understanding air dispersion (DEA, 2009). This section provides an overview of the macro scale and meso scale atmospheric circulations influencing airflow and the subsequent dispersion and dilution of pollutants.

5.1 Macro scale Air Circulations

As already mentioned vertical dispersion is governed by atmospheric stability. An unstable atmosphere is conducive to vertical movement which results in lower pollution concentrations as it is dispersed over a larger volume of air, whereas a stable atmosphere inhibits this movement and causes higher ground level concentrations. In the case of a neutral atmosphere pollution will remain at the height it is released. Unstable conditions are created when a parcel of air is warmer than the surrounding air it is released into. The parcel is less dense and therefore will rise until it reaches the same temperature and density of the surrounding air. In stable conditions the parcel is cooler and denser and therefore will sink. The vertical temperature structure of the ambient air determines whether the atmosphere is stable or not. Generally, inversion (increasing temperature with height) or isothermal (constant temperature with height) are representative of stable atmospheric conditions while lapse conditions (decreasing temperature with height) is unstable (Figure 4). Temperature inversions are often cited as the cause or poor air quality; however it is also possible to have a stable atmosphere even under lapse conditions since stability is ultimately determined by the difference in

temperature of the parcel of air and that of the ambient air at the same height (DEA 2009).

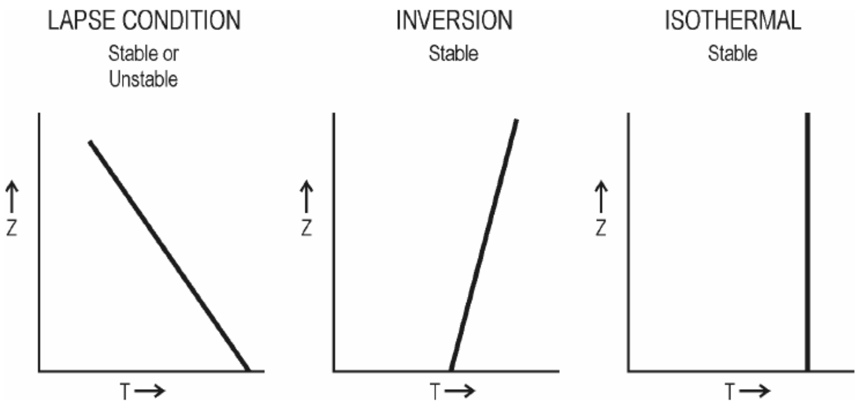


Figure 4: Variations of the environmental lapse rate (DEA, 2009).

The temperature structure of the atmosphere is directly linked to the diurnal heating cycle. During the day, solar heating of the earth's surface results in lapse conditions whereas inversions are caused by surface cooling as a result of infrared radiative transfer at night. Surface inversions are also common in valleys where cold air collects. As the surface is heated after sunrise the temperature of the lowest atmospheric layer increases causing the inversion that formed the night before to dissipate. With continued heating the inversion dissipates completely and a lapse profile forms. Around sunset, a surface inversion starts to form due to surface cooling and deepens throughout the night (Figure 5). This cycle is repeated daily and favours clear skies and calm conditions and will best develop over mid-summer and mid-winter (DEA, 2009).

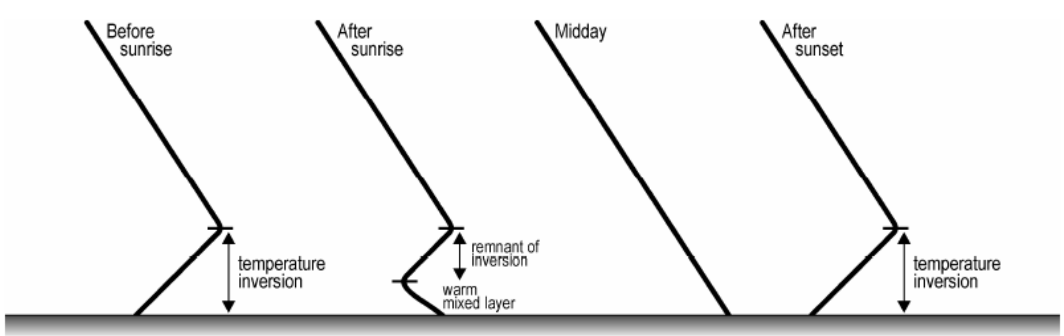


Figure 5: Change in the environmental lapse rate as a function of diurnal temperature differences (DEA, 2009).

Horizontal air movement is a function of wind speed and direction. Higher wind speeds have greater pollution dispersion potential while direction governs the impact area since it determines where the pollution is being dispersed. Wind is generated as a result of a pressure gradient in the atmosphere. Wind is produced on a range of scales (i.e.: global/large scale or local/small scale). Smaller scale systems are embedded within larger ones and the effects differ depending on the interactions between them. On a global scale a series of wind belts and semi-permanent high and low pressure belts govern climates around the planet. In terms of pollution they produce areas that either favour or inhibit dispersion (DEA, 2009). Southern Africa is dominated by three semi-permanent subtropical high pressure cells which together with the influence of easterlies in the north and westerlies in the south control the overall climate of South Africa.

The anticyclone belt centred over the subcontinent is characterised by light winds that are not conducive to wind dispersion. High pressure systems are also accompanied by stable atmospheric conditions due to subsiding air which is intensified during winter months, resulting in less dispersion potential and increased pollution concentrations (DEA, 2009). Over the interior plateau, three stable layers occur at 700 hPa, 500 hPa and 300 hPa, with another layer at 800 hPa between the escarpment and the coast. On days when these stable layers occur, dense haze layers are evident (Tyson et al., 1996). These stable layers encourage the formation of surface inversions due to nocturnal cooling, preventing the vertical dispersion of pollutants in the atmosphere reducing early morning visibility. Day time heating causes the stable boundary layer to erode allowing pollutants to disperse.

Travelling high and low pressure systems have associated weather characteristics which impact daily weather patterns. For example low pressure systems are characterised by strong winds and instability whereas high pressures systems are associated with light winds and stable conditions. The passage of these systems across South Africa is governed by the westerly wind belt situated to the south of the landmass, bringing frequent changes in stability and wind conditions, particularly for coastal regions (DEA, 2009). Cold fronts resulting from such circulations are frequent during winter months. Cold fronts are preceded by warm, clear and stable conditions as a result of subsistence while behind the front low-level convergence causes cool conditions and rain (Tyson and Preston-Whyte, 2000). Along with changes in wind direction, cold fronts are responsible

for most winter rainfall in the Western Cape which assists in cleansing the atmosphere of accumulated pollutants (Jackson and Tyson, 1971).

5.2 Meso scale air circulations

At a more localised level, circulations resulting from pressure gradients driven by temperature differences associated with uneven surface heating and topography also play a significant role in the dispersion and transportation of pollutants. Examples of these circulations are land and sea breezes along coastal regions while topographically induced winds result from complex terrain.

Differences in thermal properties between water and land surfaces produce land and sea breezes. During the day, land heats faster than a water mass, while at night water retains heat better than a land mass. The diurnal temperature differences of the two surfaces results in a pressure gradient driving localised air circulation which changes direction with the time of day (Figure 6). Sea breezes blow from the sea onto land and cause turbulence and atmospheric instability favouring the vertical dispersion of pollutants. Land breezes occur at night, blow from land to sea and are characterised by stable conditions with light winds which can transport pollution over long distances as a narrow plume. Land and sea breezes develop better during winter when nocturnal cooling is greater (DEA, 2009).

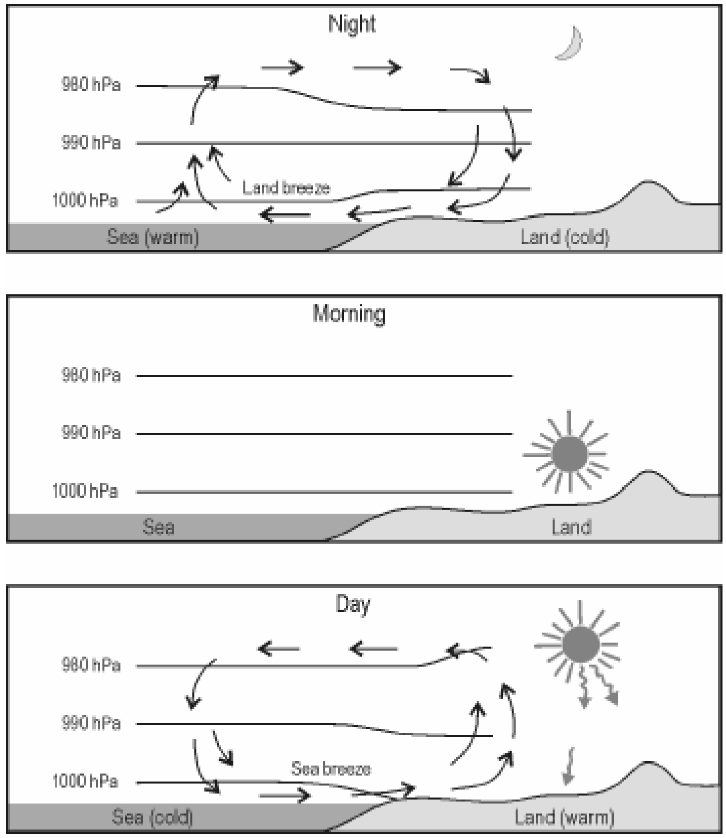


Figure 6: Diagrammatic sketch of land and sea circulations (DEA, 2009).

Topography plays an important role in air flow. Hills and valleys cause air to move in a number of ways but mostly inducing changes in direction, speed and turbulence. Other topographically induced wind circulations include *slope winds*, *valley winds* and regional *mountain-plain winds*. Slope winds flow up and down the sides of a valley as a result of differential heating and cooling between the valley floor and the valley sides. By day these wind flow upslope (anabatic winds) while at night the circulation is reversed and winds flow downslope (katabatic winds). Valley winds travel up and down the longitudinal section of a valley, flowing up the valley by day (valley winds) and down the valley by night (mountain winds) (DEA, 2009). Figure 7 illustrates this. The formation of frost hollows and the accumulation of fog and pollutants are associated with katabatic and mountain winds (Atkinson, 1981).

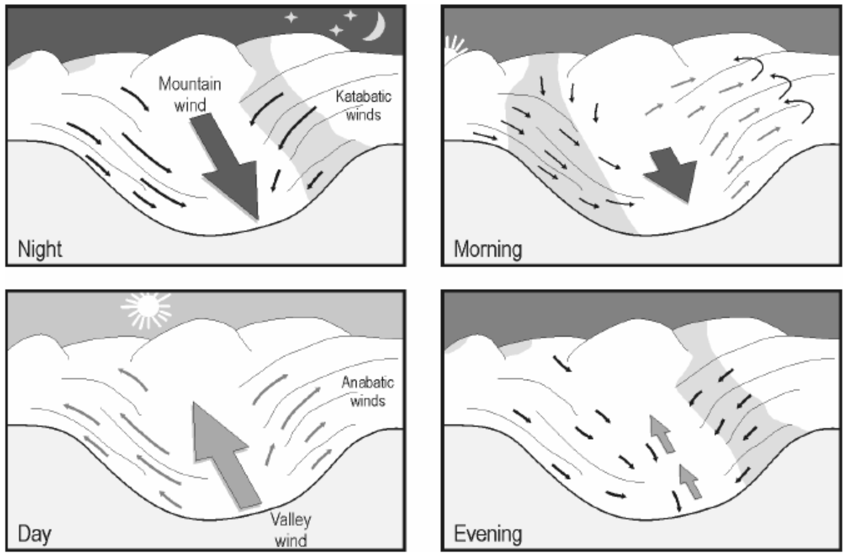


Figure 7: Diagrammatic sketch of slope and valley circulations (DEA, 2009).

In areas of fragmented topography especially where valleys lie adjacent to each other, valley/mountain winds may spill over to the surrounding terrain resulting a widespread sheet of air which travels across an entire region. These winds are known as plain-mountain winds during the day and mountain-plain winds at night.

5.3 Wind Field

Local meteorological conditions in the district are evaluated using surface meteorological data from weather stations operated by SAWS and ARC. Meteorological parameters were obtained for eight stations for the period January 2006 to December 2009. A summary of the stations used for this study is provided in Table 4.

Table 4: Meteorological stations operated by the Agricultural Research Institute and South African Weather Services in the West Coast District included in this study.

Monitoring Agency	Station Name	Latitude (°S)	Longitude (°E)	Altitude (m)	Status	Monitoring Period Obtained	Parameters Measured	Averaging Period
Agricultural Research Council	Koperfontein	-33.1	18.41796	61	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Solar Radiation, Rainfall	10 sec intervals
South African Weather Services	Clanwilliam	-32.176	18.888	107	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals
	Columbine	-32.827	17.855	55	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals
	Malmesbury	-33.472	18.718	108	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals
	Lambertsbaai	-32.034	18.332	98	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals
	Porterville	-33.012	18.976	122	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals
	Redelinghuys	-32.4810	18.536	16	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals
	Vredendal	-31.673	18.496	35	Active	January 2006 - Present	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall	5 min intervals

Wind roses summarize the occurrence of winds at a location, representing their strength, direction and frequency. Calm conditions are defined as wind speeds less than 1 $m.s^{-1}$. Each directional branch on a wind rose represents wind originating from that direction. Each directional branch is divided into segments of different colours which are representative of different wind speeds. Wind speed classes are represented as 1 – 2 $m.s^{-1}$ (slow), 2 – 4 $m.s^{-1}$ (moderate), 4 – 6 $m.s^{-1}$ (strong) and > 6 $m.s^{-1}$ (fast).

Significant variation in the wind field is observed in the West Coast District Municipality indicative of the strong underlying topographical influence on the prevailing meteorological conditions (Figure 8). The Vredendal station has prevailing winds from the west and north-west with strong winds from the south-westerly sectors. Lamberts Bay also has a strong south-westerly component as well as strong winds from the north. Columbine is located on the coastline and shows predominantly fast winds from the south. Koperfontein is situated on fairly flat terrain and experiences varying wind direction trends. Winds from the east-south-east, west-south-west and north-west are evident. Observations for Clanwilliam, Redelinghuys, Porterville and Malmesbury revealed similar direction patterns most likely due to the presence of the mountain range to their right. All four stations have distinct northerly and southerly wind patterns while Clanwilliam and Redelinghuys also have an easterly component. Clanwilliam, Porterville and Malmesbury had between 30% and 40% calm conditions. Koperfontein also had high incidence of calm conditions while the other stations had infrequent periods of calm.

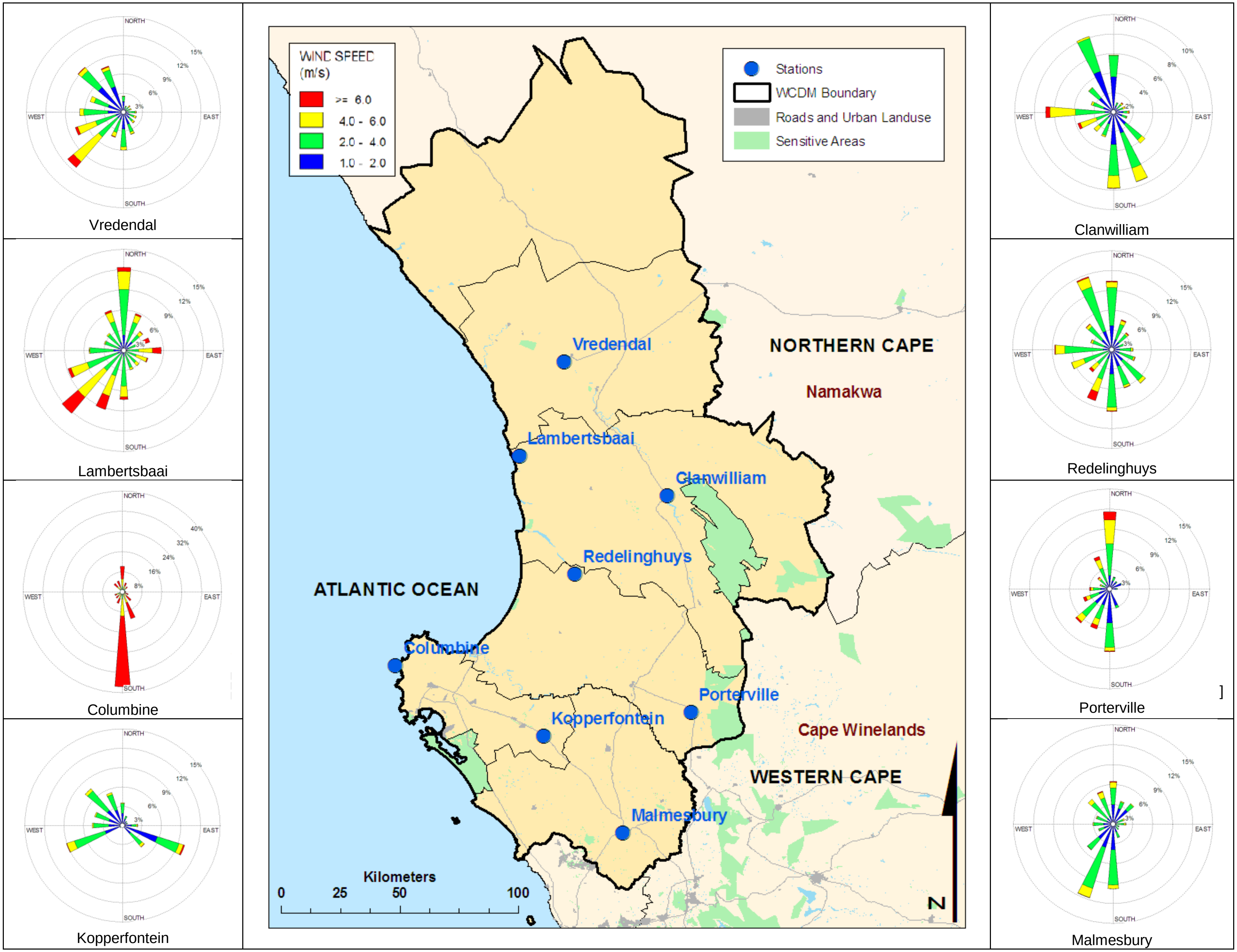


Figure 8: **Period surface wind roses for the West Coast District Municipality for the period 2006 – 2009.**

The diurnal variation in winds in the West Coast District is given in Figures 9 – 12. The micro-scale influence of the underlying topography on wind patterns is evident in the diurnal signatures recorded at the meteorological stations.

The Vredendal station has winds originating predominantly from a north-westerly direction in the mornings which switches to strong south-westerlies in the afternoon and evening. Lamberts Bay has prevailing northerly and southerly winds in the morning with additional components from the east which dissipate into the afternoon and evening when wind directions change to strong south-westerlies. Wind direction at Columbine remains relatively unchanged from day to night. Winds are predominantly south with occasional northerlies (10% of the time) during the morning which dissipate into the afternoon and evening as the southerlies become more intense and frequent. Koperfontein experienced a high percentage of calm conditions throughout the morning and in the evening with calms occurring only 7% of the time in the afternoon. In terms of wind orientation, airflow varies significantly from north-west in the early morning, to east-south-east in the mid-morning which remains into the afternoon. A west-south-westerly wind also develops in the afternoon and intensifies into the evening. Clanwilliam and Redelinghuys show similar circulations with distinct northerly and southerly wind patterns during the morning hours, while afternoon and evening airflow is characterised by strong westerlies and southerlies respectively. Clanwilliam has a higher frequency of calm conditions compared to Redelinghuys. Porterville shows a distinct diurnal variation, with morning winds originating in the north which dissipate into the afternoon with the development of strong southerlies. Although Malmesbury has minor variability in wind direction it generally shows the same airflow pattern as Porterville with morning northerlies and evening southerlies.

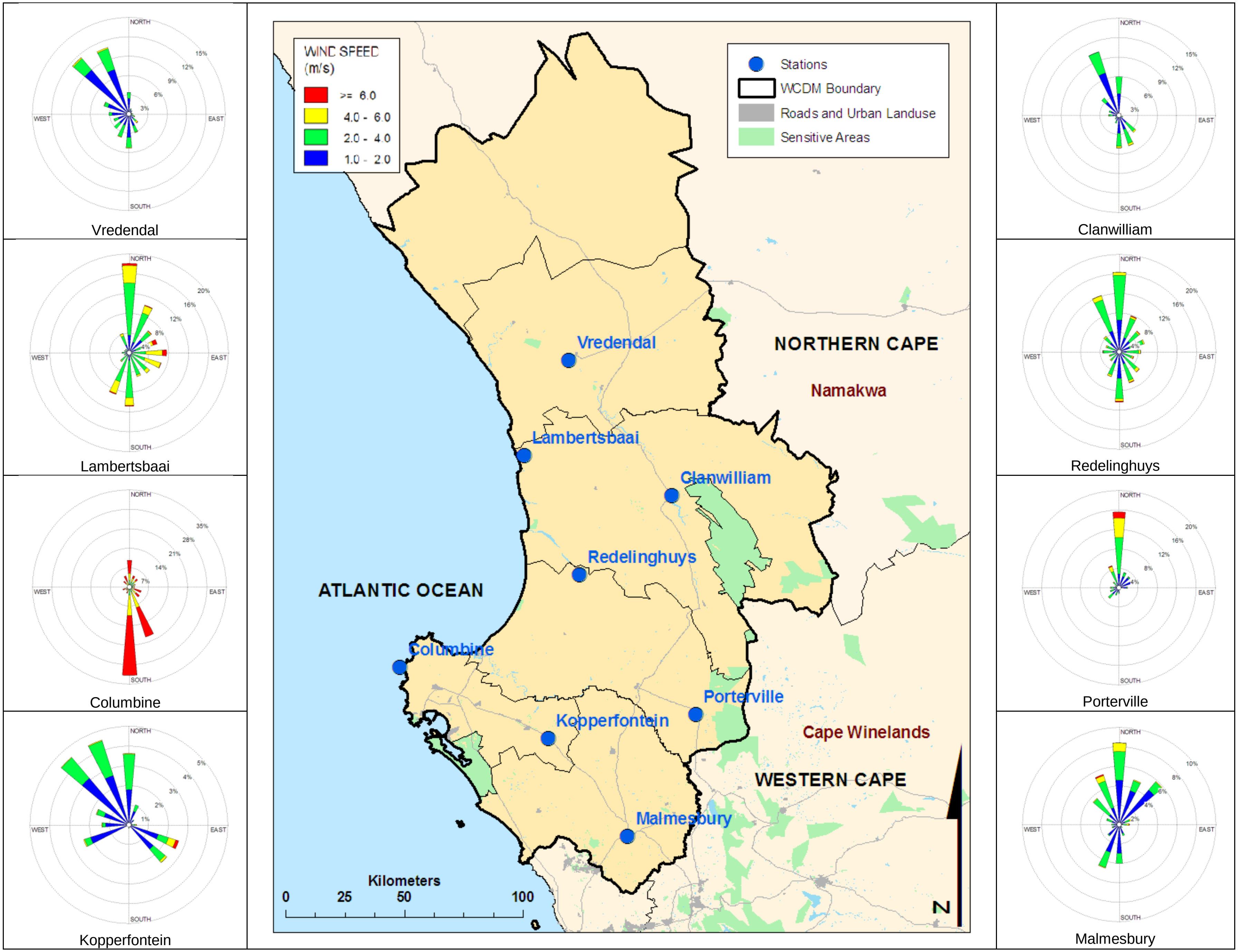


Figure 9: **Diurnal wind roses (00:00 – 06:00) for the West Coast District Municipality for the period 2006 – 2009.**

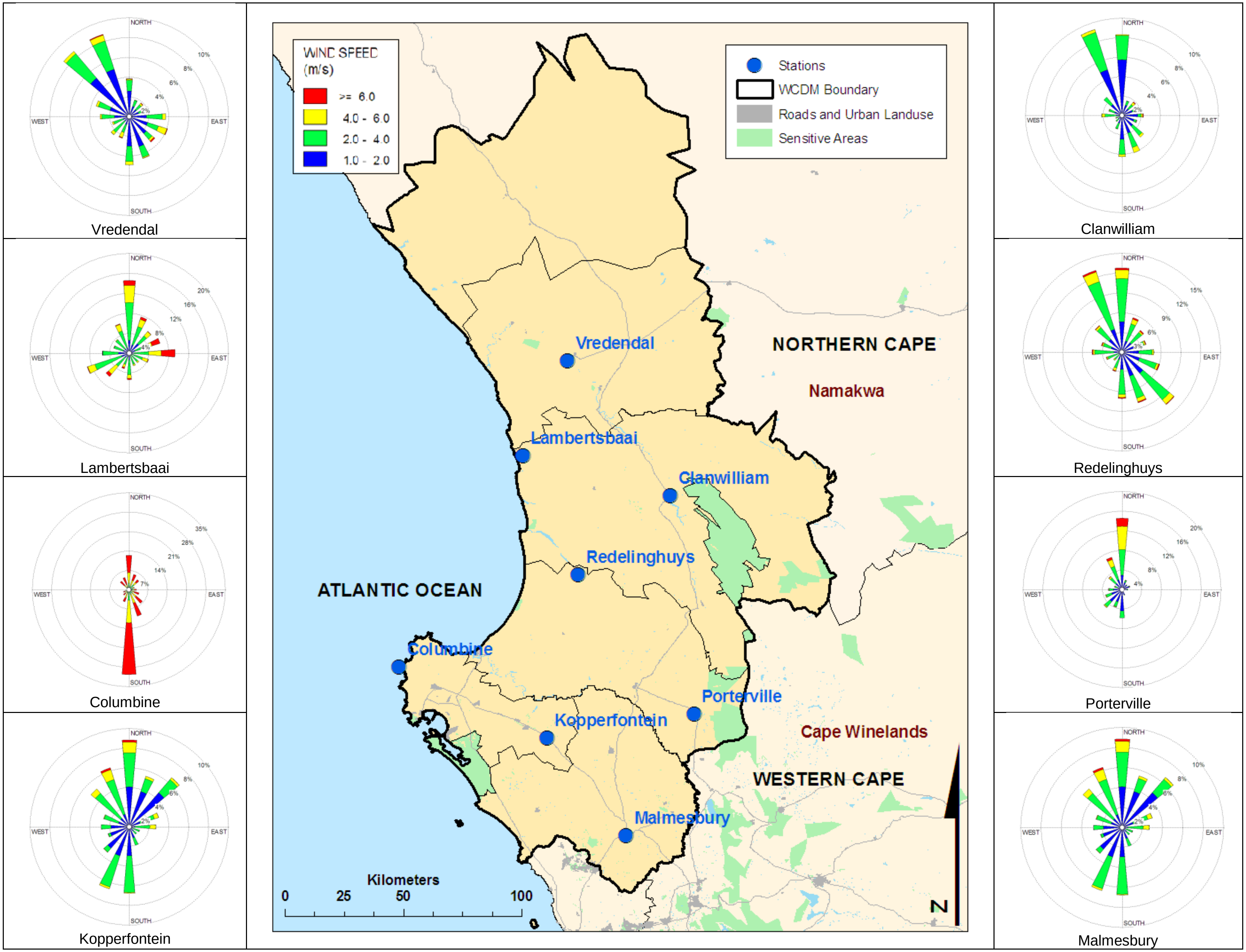


Figure 10: **Diurnal wind roses (06:00 – 12:00) for the West Coast District Municipality for the period 2006 – 2009.**

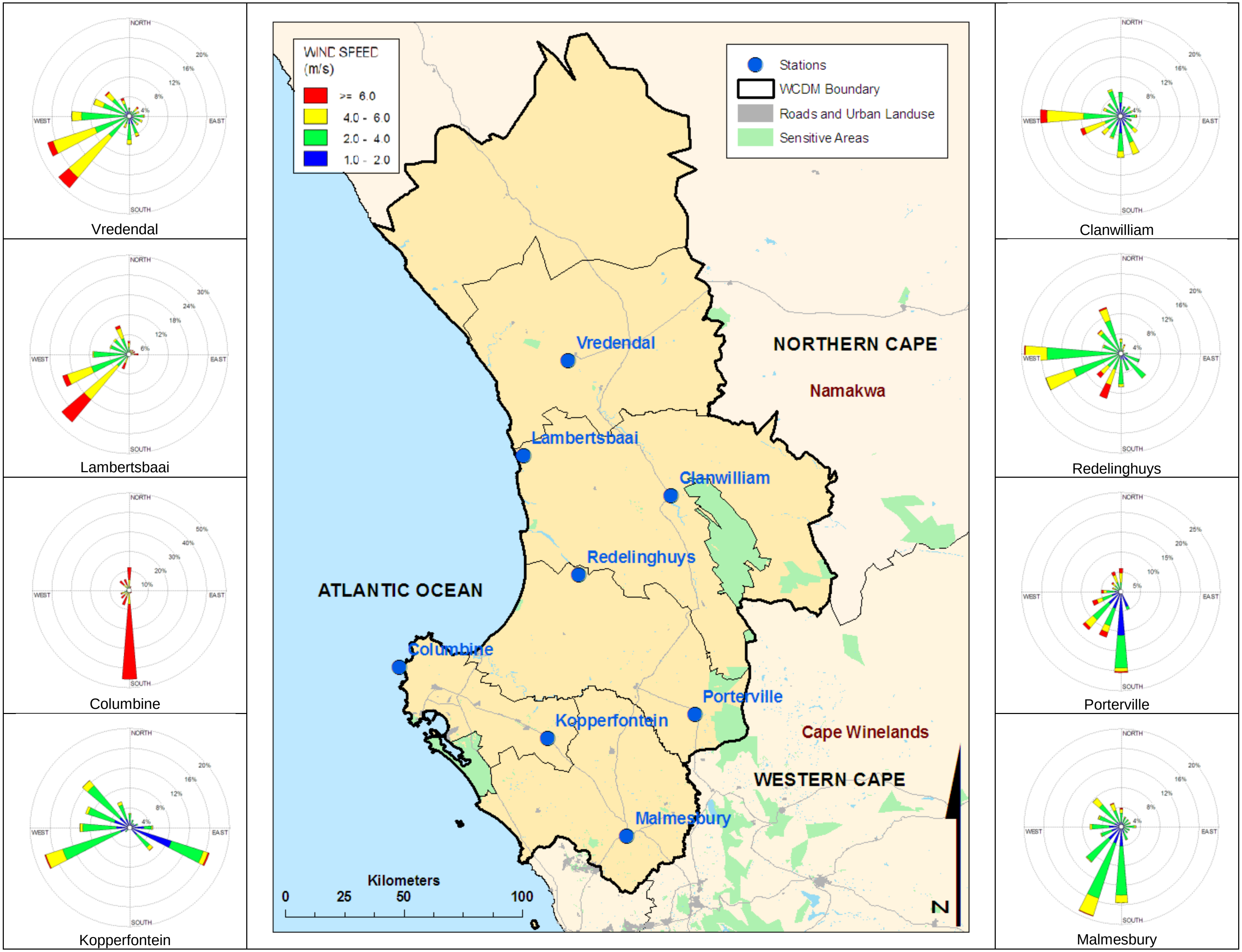


Figure 11: **Diurnal wind roses (12:00 – 18:00) for the West Coast District Municipality for the period 2006 – 2009.**

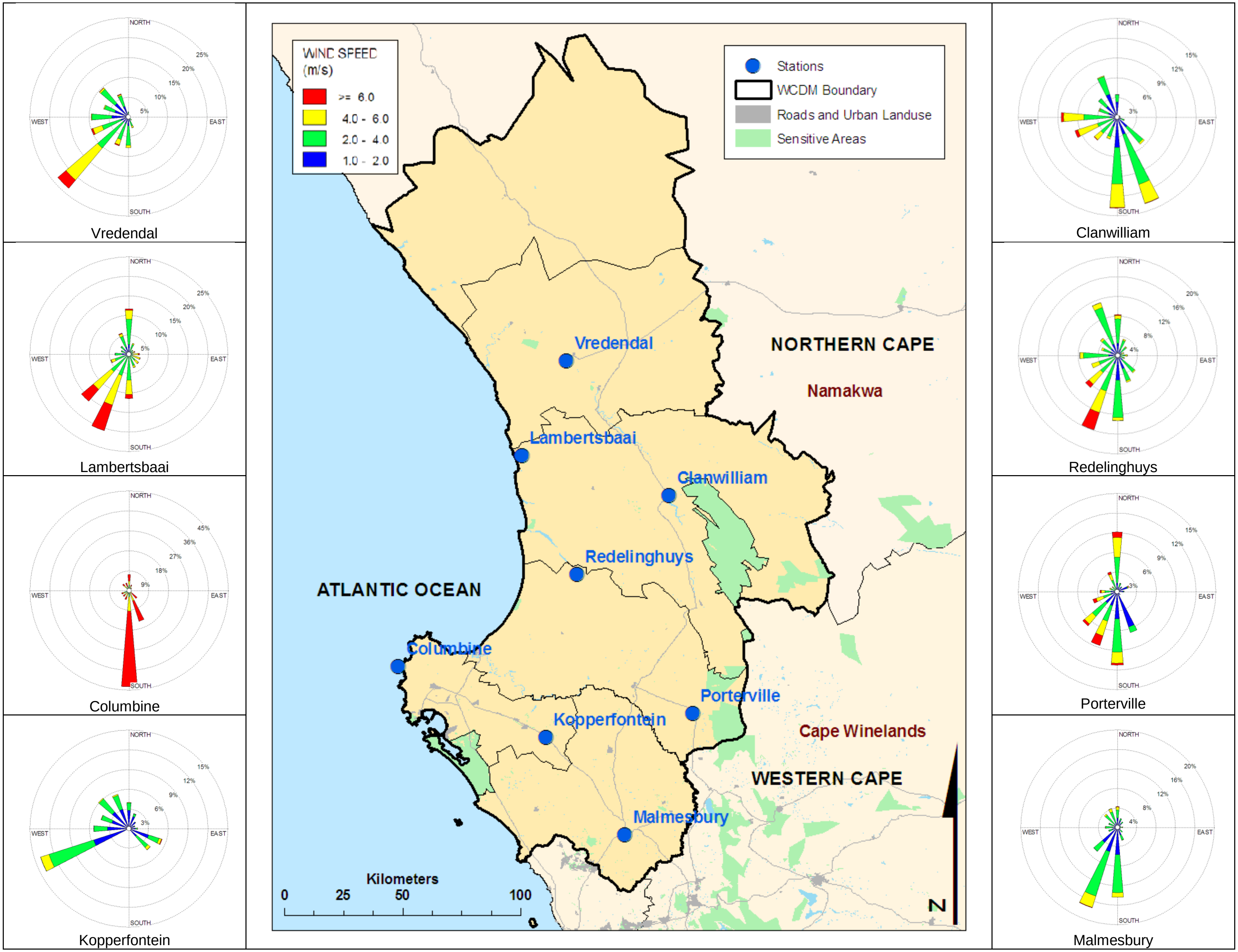


Figure 12: **Diurnal wind roses (18:00 – 24:00) for the West Coast District Municipality for the period 2006 – 2009.**

5.3.1 Temperature

Long-term average maximum, minimum and mean temperatures for Malmesbury and Lambert's Bay are given in Figure 13 and Figure 14. Average maximum temperatures range from 31 °C in February to 12 °C in July in Malmesbury, with average minimums ranging from 14.9 °C in February to 5.8 °C in July. In Lambert's Bay, similar temperatures are recorded with average maximum temperatures ranging from 25.5 °C in February to 18.4 °C in August, with average daily minima ranging from 14.6 °C in February to 8.4 °C in August.

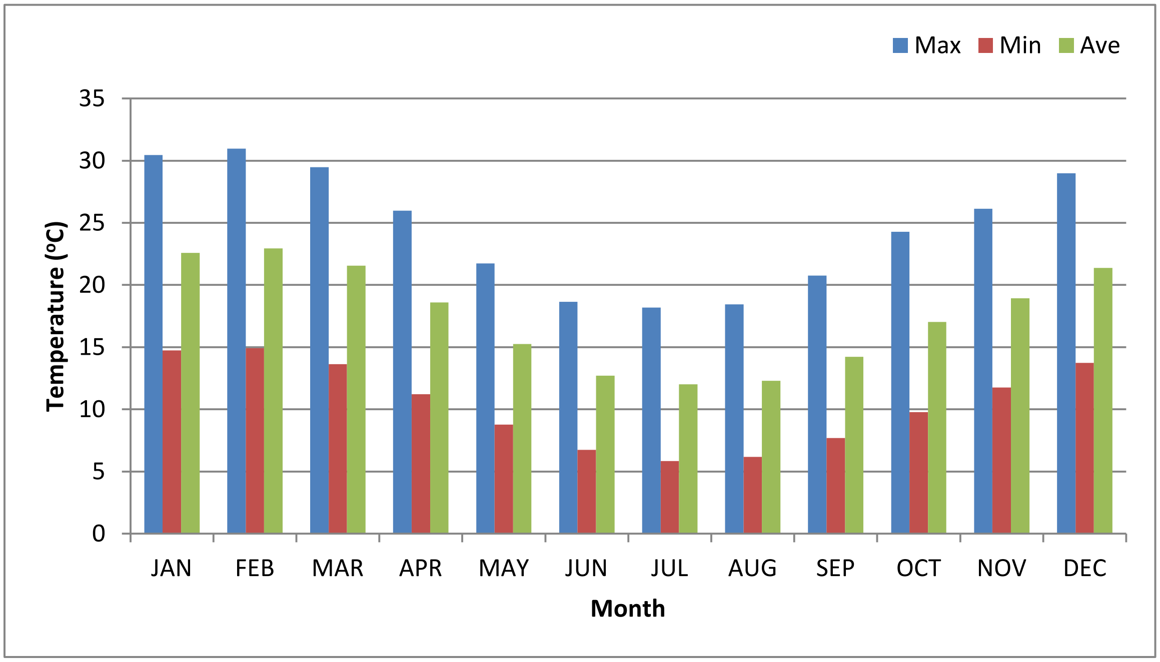


Figure 13: Long term temperature (^{o}C) for Malmesbury for the period 1990 – 2009.

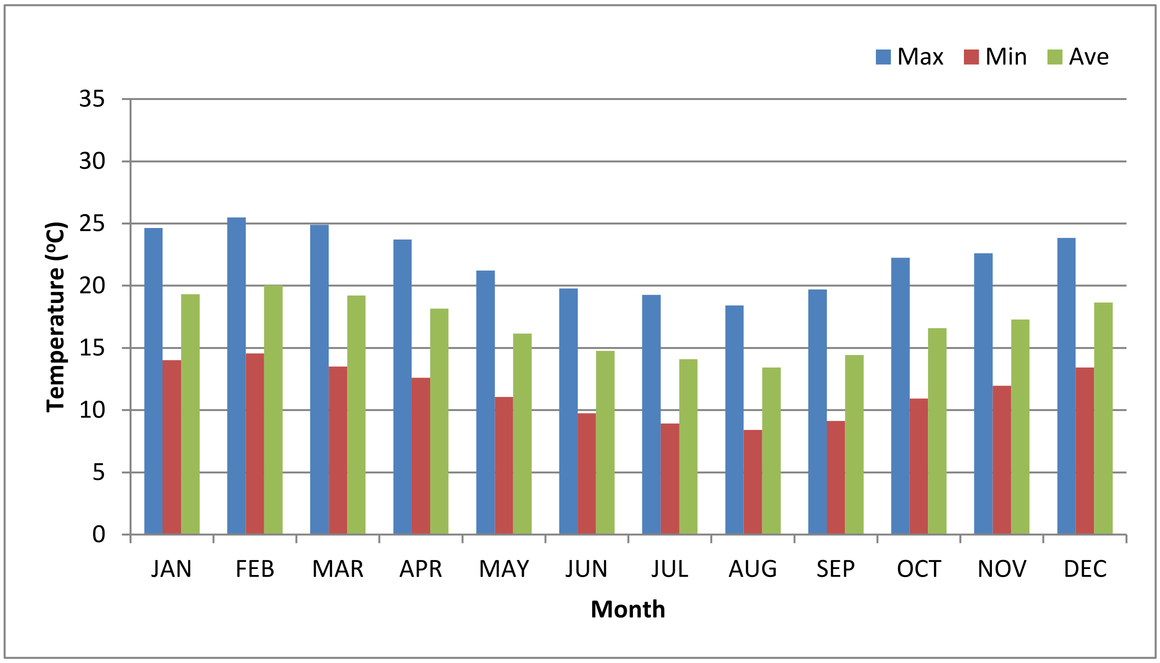


Figure 14: Long term temperature (°C) for Lambert's Bay for the period 1990 – 2009.

5.3.2 Precipitation

The West Coast District experiences a marked seasonality of precipitation with cool, wet winters and warm, dry summers, characteristic of a Mediterranean climate. Winter precipitation is mainly from a westerly direction due to cold fronts crossing the South Atlantic and Southern Oceans. Monthly rainfall averages for Malmesbury measured over a period of 44 years, varied between 78 mm in June and 9.9 mm in January. For a period of 133 years, lower volumes of precipitation were recorded in Lambert's Bay; however still indicate increased precipitation during the winter season (June, July and August). Monthly precipitation is given in Figure 15 and Figure 16 for Malmesbury and Lambert's, respectively.

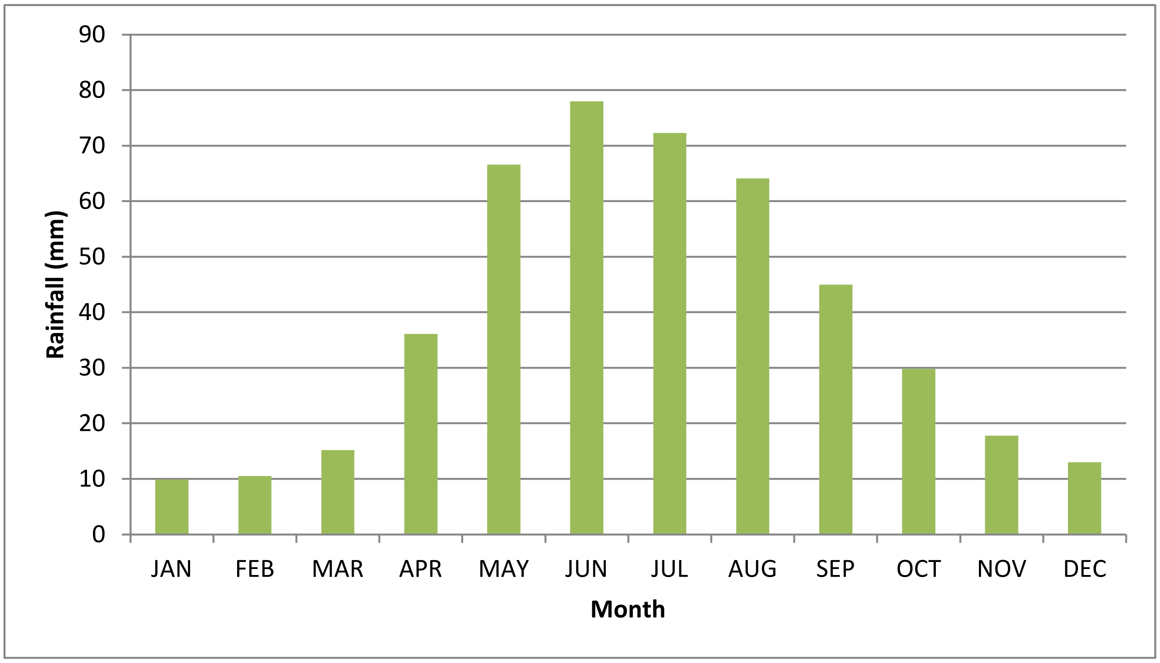


Figure 15: **Average monthly rainfall (mm) for Malmesbury for the period 1966 – 2010.**

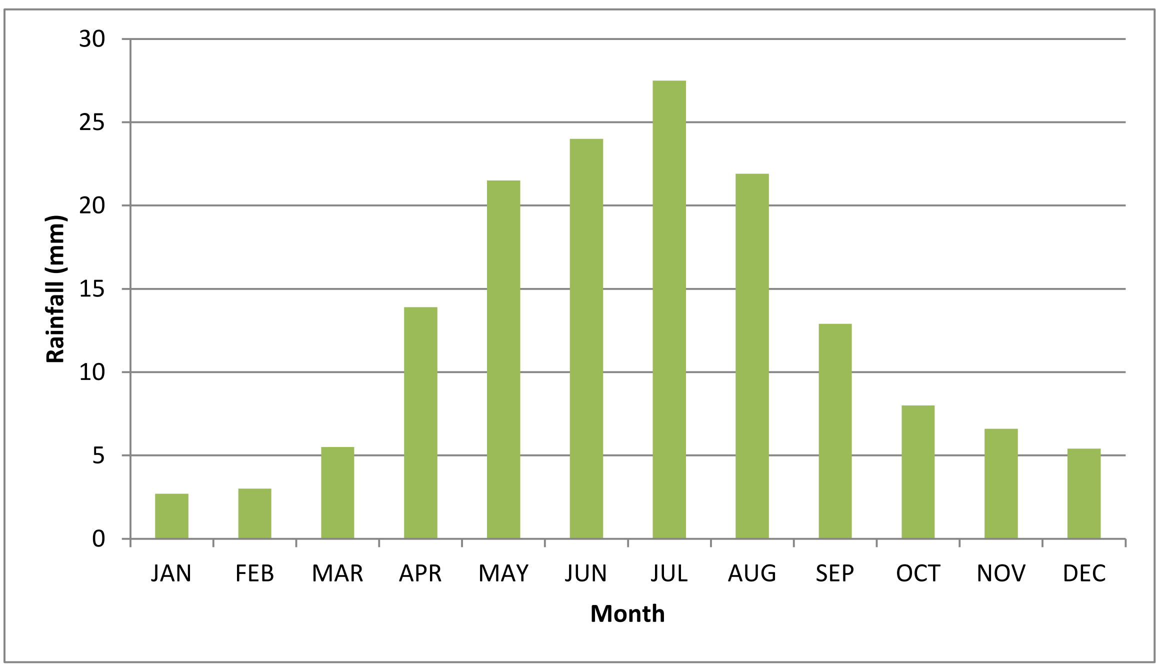


Figure 16: **Average monthly rainfall (mm) for Lambert's Bay for the period 1877 – 2010.**

6. STATUS QUO OF THE AMBIENT AIR QUALITY IN THE WEST COAST DISTRICT

6.1 Current Ambient Air Quality Situation

Ambient air quality monitoring information that was received for the District was collated and is discussed in this section. Continuous monitoring campaigns are mostly run by industry. ArcelorMittal Vredenburg Exxaro Namakwa Sands and the Port of Saldanha operate monitoring stations and have been contacted for data. Data was received from the Port of Saldanha and ArceloMmittal. The Western Cape Provincial Government also operates an ambient network of four mobile stations where NO_2, SO_2, O_3, PM_{10}, CO and CO_2 levels are measured. One station was situated at Vredenburg and has recently been relocated to Malmesbury. Data was received for the Vredenburg station before it was moved to Malmesbury, the data for the relocated station was requested but not received. The other three are located outside the West Coast District. A map indicating the locations of the air quality monitoring stations is included below.

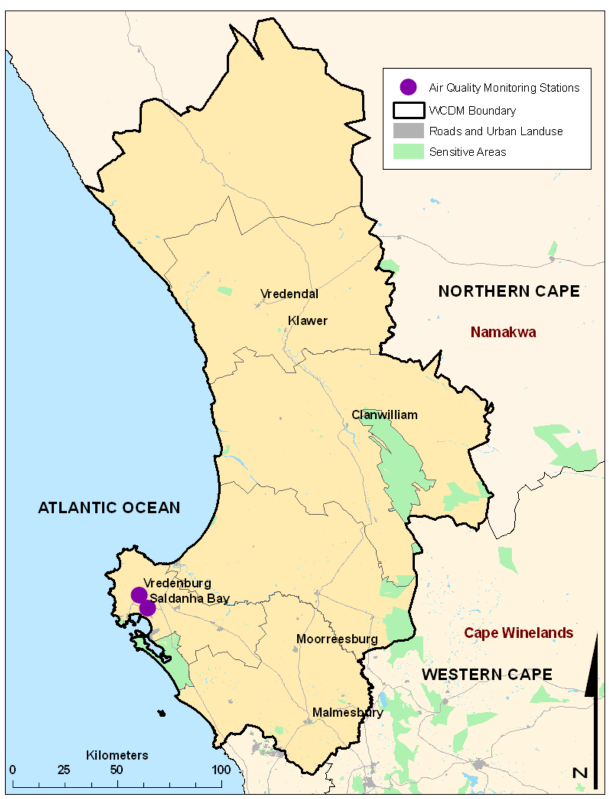


Figure 17 Air Quality Monitoring Stations in the WCDM

Below are graphs that show the concentrations of pollutants measured at Vredenburg and Saldanha Bay. The data that are displayed in the following tables are the only data that were received. These areas have been identified as the area where the most industrial operations take place. Although the data only portray sections of the overall air quality monitoring data, no exceedances are visible. This shows that the air quality in the most industrialised areas within the WCDM is still well within the national standards. The conclusion was made that the rest of the WCDM does not have an Air Quality problem.

The Vredenburg Monitoring Station's data that were received range from May 2008 to March 2010. The data displayed for Vredenburg Hills and Blue Water Bay range from 2008 to 2010.

Most industrial activities in the WCDM are situated in the Vredenburg and Saldanha Areas. The level of pollutants measured, PM_{10}, SO_2 and NO_2 are shown. The concentrations of pollutants are highest in these areas but they still remain far below the National Air Quality Standards. (Table 3) The aim of the AQMP is to ensure that the air quality in the WCDM is maintained.

The Vredenburg Monitoring Station was moved to Malmesbury in March 2010.

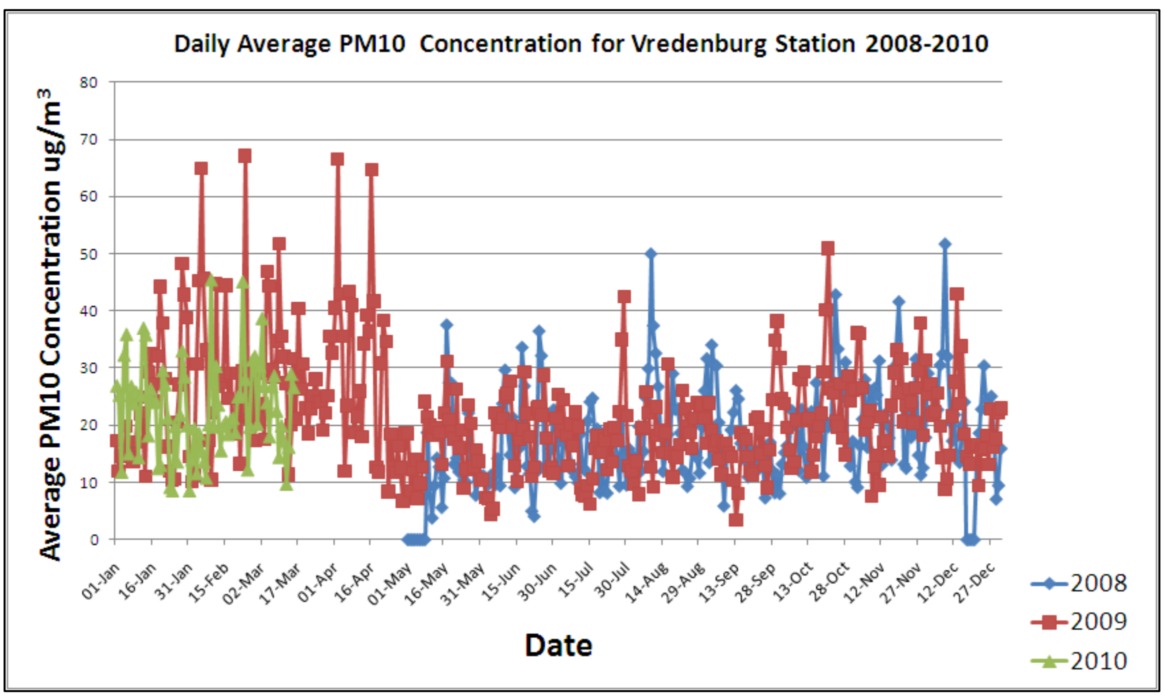


Figure 18 Daily average PM_{10} Concentration for the Vredenburg Monitoring Station 2008-2010

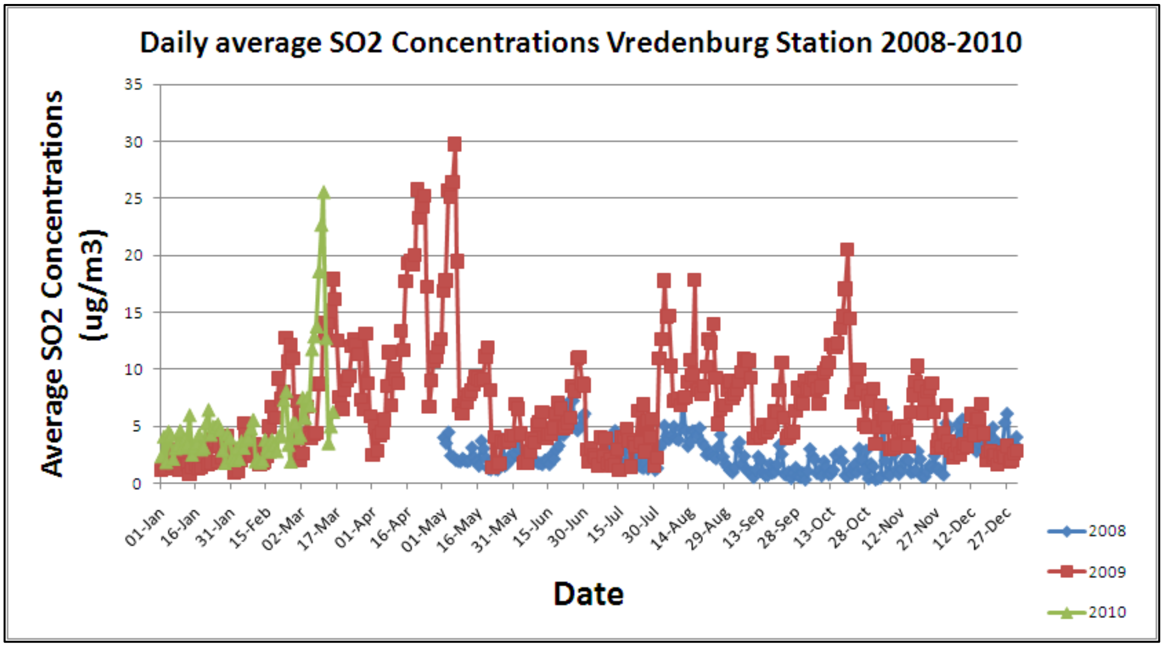


Figure 19 Daily average SO_2 Concentration for the Vredenburg Monitoring Station 2008-2010

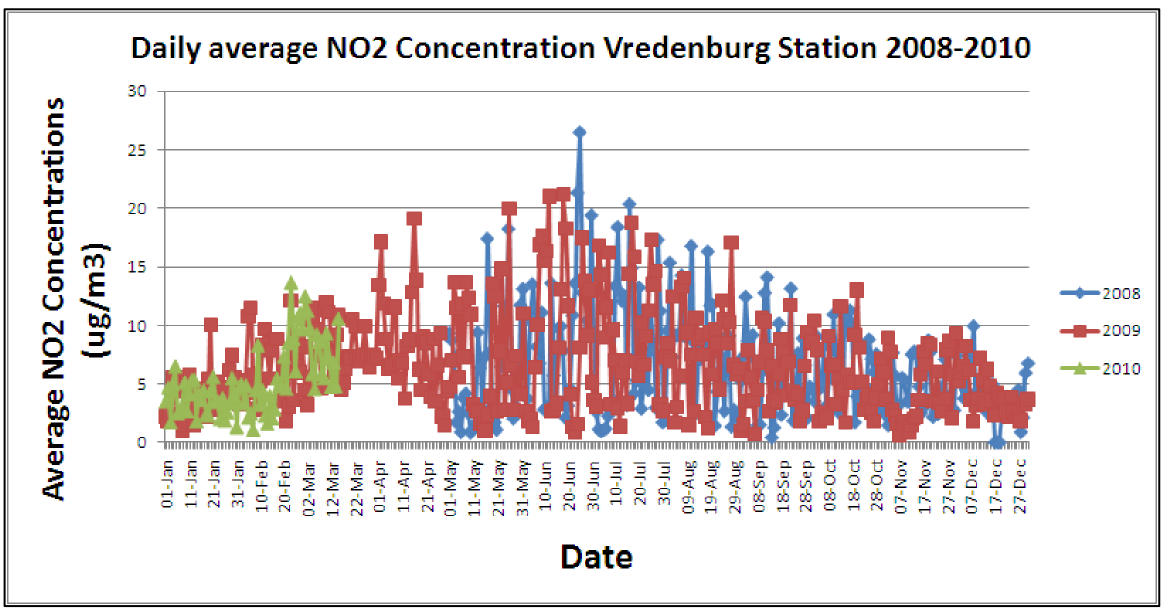


Figure 20 Daily average NO_2 Concentration for the Vredenburg Monitoring Station 2008-2010

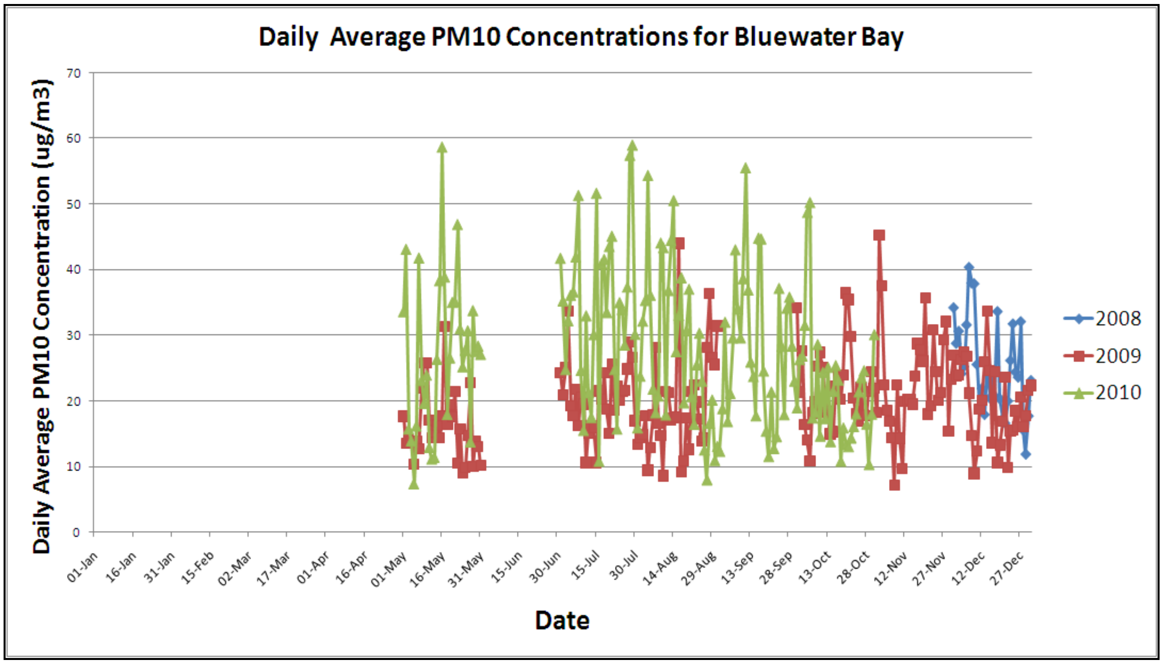


Figure 21 Daily average PM_{10} Concentration for the Bluewater Bay (Port of Saldanha) 2008-2010

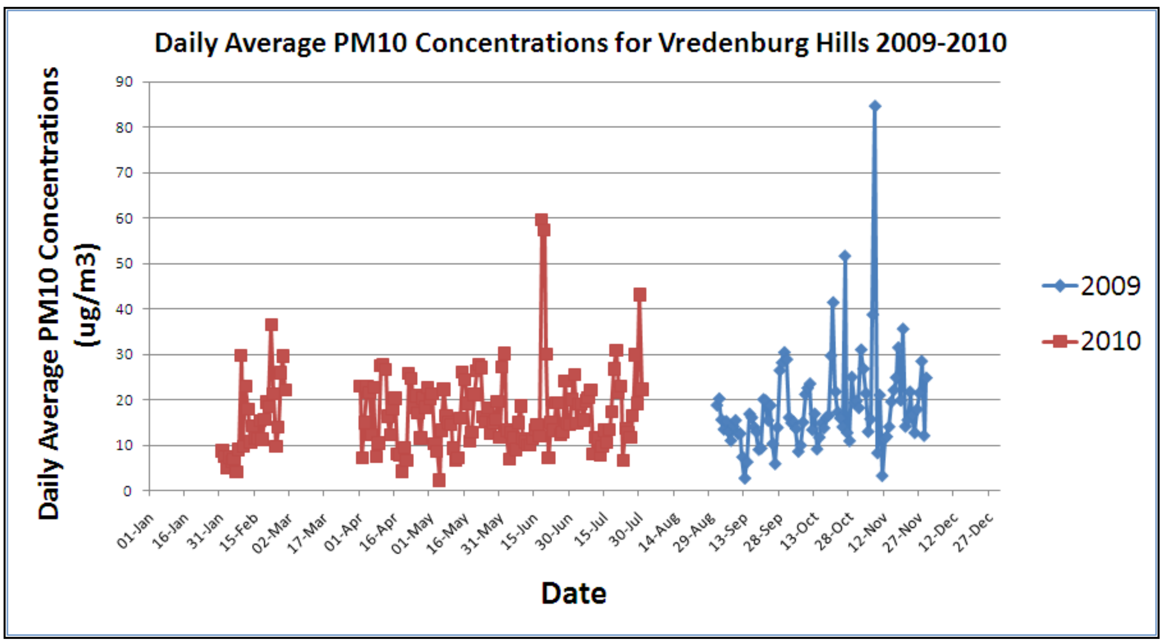


Figure 22 Daily average PM_{10} Concentration for Vredenburg Hills (Port of Saldanha) 2009-2010

6.2 Baseline Emissions Inventory

An emissions inventory for the West Coast was compiled for air pollution sources where information was available or where emission factors could be applied to quantify emissions. Potential air pollution sources in the West Coast have been identified as:

- Industrial operations,
- Agricultural activities such as spraying of agrochemicals,
- Mining Activities – Mining activities and Port of Saldanha Iron ore
- Biomass burning (veld fires),
- Domestic fuel burning (particularly, wood and paraffin),
- Vehicle tailpipe emissions,
- Waste treatment and disposal (landfills and incineration),
- Vehicle entrainment of dust from paved and unpaved roads,
- Other fugitive dust sources such as wind erosion of exposed areas.

Particulate and gaseous emissions from industrial operations, domestic fuel burning and vehicle tailpipe emissions were quantified for this assessment, due to the availability of data for these sources. Emissions from other sources could not be accurately quantified due to the limited availability of data and information. However, it is recognised that some of these sources, in particular, agricultural activities and biomass burning, are significant contributors to the ambient air quality in the District.

Ambient pollutants that were assessed include the criteria pollutants, SO_2, NO_2 and PM10.

6.2.1 Industries

Listed Activities (formerly known as scheduled processes), as defined by the Air Quality Act, are activities that emit more than a defined quantity of pollutants per year. No person may carry on a listed activity in or on any premises unless he is the holder of a current atmospheric emission license (formerly known as a registration certificate). Within the West Coast District, listed activities include brickworks, metal processors, cement factories and fishmeal manufacturers among others (Table 5).

Table 5: Types of listed activities in the West Coast District Municipality.

Process Description	Bergrivier	Cederberg	Matzikama	Saldanha Bay	Swartland
Process 7: Hydrochloric Acid Processes				✓	
Process 22: Cement Processes	✓				✓
Process 30: Iron and Steel Processes				✓	
Process 35: Ceramic Processes			✓	✓	✓
Process 39: Waste Incineration Processes		✓			
Process 55: Galvanising Processes				✓	
Process 59: Bulk Storage of Ore or Coal				✓	
Process 67: Wood Burning and Drying Processes					✓
Process 69: Animal Matter Reduction Processes	✓			✓	✓

Overall, West Coast District is not considered to be an industrialized area with most industries located in major urban areas, and along major roads connecting these urban areas. Most large to medium scale industry is concentrated in the Saldanha Bay and Swartland Local Municipalities. Industries are located around the town of Vredenburg and along the coast line in Saldanha Bay while industrial areas of Swartland include Malmesbury and Morreessburg. The spatial distribution of industrial sources in the West Coast District Municipality is shown in Figure 17.

Figure 23: **Spatial distribution of industrial sources in West Coast District Municipality (for industries where coordinates were obtained).**

An emission inventory of industrial sources in West Coast was compiled using information obtained from the Western Cape Province APPA Registration Certificate database. This was updated and verified through information provided by the District Municipality and Local Municipalities as well as direct correspondence with industries in the region. Main industries within each Local Municipality have been identified as:

Bergrivier – La Vie Seafood Products, Marine Products and Pretoria Portland Cement (De Hoek).

Cederberg – Ceder Pack, Citrus Juices, Citrusdal Hospital, Goeie Hoop Cirtus, Khoisan Tea, Nu Season, Red T Company and Clanwilliam Hospital.

Matzikama – Exxaro TSA Sands, Koelby, Namakwa Stene, Noordwest Steengroewe, Trans Hex Mynbou Beperk and Vredendal Hospital.

Saldanaha Bay – Duferco, Exxaro Namakwa Sands, Hannasbaai Fishing Company, Norsenet, Oceana, Pioneer Oranjevis, ArcelorMittal, Van Dyk Precast, Vredenburg Hospital,West Point Processors and Cape Lime.

Swartland – AquaNutro, Bonwit, Darling Dairy, Darling Hoender Abattoir, Pioneer Foods: Nova Voere, International Wire Distributors, J&J Brickworks, McMillan Brick Sand, Mortar SA, Petfood Caterers, Pioneer Foods: Sasko Pasta, Pretoria Portland Cement (Riebeek West), Roelcor Vleis, Bokomo Sugar Bird, Swartland Afalprodukte, Swartland Boudienste, Swartland Hospital, Swartland Winery and Titan Lime Company.

Table 6: Summary of Industrial Sources in the West Coast District Municipality.

Municipality	Source	Process Description	Latitude (S^o)	Longitude (E^o)
Bergrivier	La Vie Seafood Products	Fish species procurement/processing/canning	32° 46' 24.8592"	18° 9' 14.349"
	Marine Products	Fish species procurement/processing/canning		
	Pretoria Portland Cement (De Hoek)	Cement manufacturing		
Cederberg	Ceder Pack	Packaging	32° 35' 27.86"	19° 00' 45.15"
	Citrus Juices			
	Citrusdal Hospital	Hospital	32° 35' 47.94"	19° 00' 59.80"
	Goeie Hoop Citrus	Citrus packaging	32° 35' 17.37"	19° 00' 43.19"
	Khoisan Tea	Rooibos tea processing and packaging		
	Nu Season			
	Red T Company	Rooibos tea processing and packaging	32° 16' 49"	18° 53' 33"
	Clanwilliam Hospital	Hospital	32° 11' 1.7478"	18° 53' 27.2898"
Matzikama	Exxaro TSA Sands	Mineral sand seperation	31° 14' 6.7488"	17° 54' 47.4186"
	Koelby	Bottling plant	31° 38' 51.9282"	18° 31' 2.6004"
	Namakwa Stene	Brick manufacturing	31° 46' 39.4788"	18° 36' 49.8702"
	Noordwest Steengrowe			
	Trans Hex Mynbou Beperk	Diamond mining		
	Vredendal Hospital	Hospital	31° 40' 12.78"	18° 30' 18.13"
Saldanha Bay	Duferco	Steel production processing	32° 58' 38.301"	17° 59' 41.7012"
	Exxaro Namakwa Sands	Steel production processing	32° 58' 17.8716"	18° 1' 40.9002"
	Hannasbaai Fishing Company	Fish species procurement/processing/canning	32° 45' 4.6908"	18° 0' 59.529"
	Norsenet	Net manufacturing	32° 54' 08.35"	19° 59' 32.16"
	Oceana	Fish species procurement/processing/canning	32° 84'58.33"	19° 13' 19.44"
	Pioneer Oranjevis	Fish species procurement/processing/canning	32° 44' 49.941"	18° 0' 39.5994"
	Arcelormittal	Steel production processing	32° 58' 36.79"	18° 01' 11.88"
	Van Dyk Precast	Brick manufacturing	32° 54' 08.35"	18° 00' 04.20"
	Vredenburg Hospital	Hospital	32° 54' 51.46"	17° 59' 32.16"
	West Point Processors	Fish species procurement/processing/canning	32° 46' 40.0002"	18° 2' 57.0012"
Swartland	AquaNutro	Animal feed production	33° 27' 41.30"	18° 43' 48.60"
	Bonwit	Clothing manufacturing	33° 20' 20.17"	18° 23' 12.33"
	Darling Dairy	Dairy production	33° 21' 40.39"	18° 23' 24.07"
	Darling Hoeder Abattoir	Abattoir		
	Pioneer Foods: Nova Voere	Animal feed production	33° 27' 58.57"	18° 43' 25.04"
	International Wire Distributors			
	J&J Brickworks	Brick manufacturing		
	McMillan Brick Sand			
	Mortar SA	Mortar dry mix		
	Petfood Caterers	Animal feed production	33° 9' 12.3078"	18° 40' 16.0392"
	Pioneer Foods: Sasko Pasta	Pasta Product manufacturing	33° 28' 11.51"	18° 43' 53.73"
	Pretoria Portland Cement (Riebeek West)	Cement manufacturing		
	Roelcor Vleis	Meat packaging and distribution		
	Bokomo Sugar Bird	Glacé fruit manufacturer	33° 28' 13.5336"	18° 43' 52.7304"
	Swartland Afvalprodukte	Abattoir		
	Swartland Boudienste	Wood drying	33° 9' 0.3096"	18° 40' 44.1006"
	Swartland Hospital	Hospital	33° 27 ' 09.43"	18° 43' 24.82"
	Swartland Winery	Wine distilling		
	Titan Lime Company			

Table 7 Businesses that use small boilers in the WCDM

Name of company	Nature of Business	Type of Boiler(s)	Fuel Used	Latitude	Longitude
Duferco Steel Processing	Steel Processing	horizontal burner, after burner, direct combustion gas burner	LPG/Propane, H2	32°58'38.3"	17°59'41.7"
Clanwilliam Hospital	Hospital	Vertical boiler, standby generator	paraffin, diesel	32°11'21.48"	18°53'22.56"
Exxaro SA Sands-Namakwa Sands	Heavy Minerals Sands	Horizontal burner	coal,paraffin	32°58'019.57'	17°56'14.04"
Exxaro SA Sands	Titanium Slag - smelting	Fluid bed drier	CO gas, light oil		
Koelbly (Edms) Bpk	Bottler of carbonated soft-drinks	coal fired boiler	coal	31°33'26.3"	18°21'4.00"
Hannasbaai Fishing Company	Fishmeal Processing	Horizontal boiler	HFO, coal	32°45'04.69"	18°00'59.53"
La Vie Seafood Products	Mussel Factory	Vertical boiler	paraffin		
Namakwa Stene	Clay Brick Manufacturing	Coal fired boiler	coal	31°46'39.46"	18°36'49.87"
Pioneer Fishing (West Coast) - Oranjevis	Fish canning and fish meal production	Horizontal boiler	coal	32°44'49.94"	18°0'39.60"
Petfood Caterers	Food	Horizontal boiler	HFO	33°09'12.31"	18°40'16.04"
Bokomo Foods Sugarbird	FMCG	Horizontal steam boiler,fire tube horizontal burner	Coal, HFF	33°47'04.26"	18°73'13.14"
Swartland Boudienste	Building services	Fire tube horizontal burner	Wood Waste	33°09'03.1"	18°40'44.1"
Swartland Winery	Winecellar	Coal fired boiler	Coal		
West Point Processors	Fish meal processing/Canning	Horizontal boilers	Coal, HFO	33°46'40"	18°02'57"

Figure 24 Spatial Distribution of businesses that use small boilers in the WCDM

Emissions for the identified industries were quantified using the emission factors from the Australian National Pollution Inventory (Table 8) and the provided fuel usage in the West Coast emissions inventory database. Coal is the predominant fuel used by industries in the District although electricity, diesel, paraffin, wood, Heavy Fuel Oil (HFO) and Liquid Petroleum Gas (LPG) are also used.

Table 8: Emission factors for determining emissions from fuel burning appliances (NPI, 2008).

Fuel	Unit	SO_2	NO_x	CO	PM10
Coal	kg/ton	0.57	5.5	2.5	6.6
Diesel	kg/ton	0.579	2.72	0.68	0.14
HFO	kg/ton	0.627	7.32	0.67	0.0542
LPG	kg/ton	0.000105	4.43	0.76	0.24
Wood	kg/ton	0.17	1.49	4.08	3.24
LSO	kg/ton	0.627	7.32	0.67	0.0542

Emission rates for each source were then calculated using the formula:

$$E_{\chi} = F_{\chi} \times Q_{fuel}$$

Where,

E_{χ} = emission rate of pollutant (kg/year)

F_{χ} = emission factor (kg/ton)

Q_{coal} = fuel consumption (tons/year)

The total contribution of each Local Municipality to PM10, SO_2 and NO_x emissions from industries in the District could not be calculated due to the poor response from industry. It is expected that Saldanha Bay and Swartland are the main contributors to industrial emissions in the district due to the number and heavy nature of industry in those areas.

6.2.2 Domestic Fuel Burning

Although a high percentage of households have access to electricity in the District, some household's still use fuels such as paraffin and wood for cooking and heating purposes (Table 9). Rapid urbanization and the growth of informal settlements have resulted in backlogs in the provision of basic services such as electricity and waste removal. Therefore, in some areas, these fuels continue to be used due to their cost effectiveness and multi-functional nature.

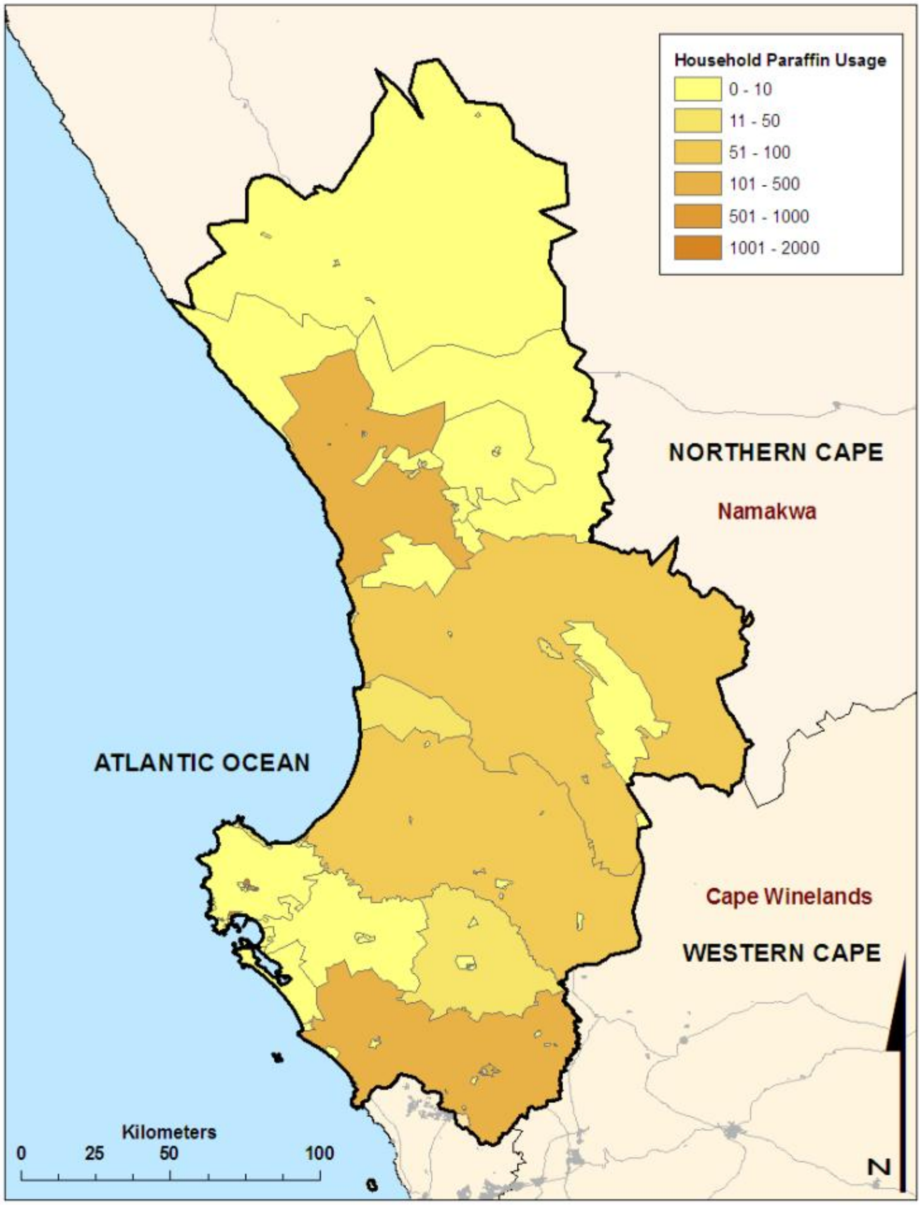
Pollutants released from these fuels include CO, NO_2, SO_2, inhalable particulates and polycyclic aromatic hydrocarbons. Particulates are the dominant pollutant emitted from the burning of wood. Smoke from wood burning contains respirable particles that are small enough in diameter to enter and deposit in the lungs. These particles comprise a mixture of inorganic and organic substances including aromatic hydrocarbon compounds, trace metals, nitrates and sulphates. Polycyclic aromatic hydrocarbons are produced as a result of incomplete combustion and are potentially carcinogenic in wood smoke (Maroni *et al*., 1995). The main pollutants emitted from the combustion of paraffin are NO_2, particulates, carbon monoxide and polycyclic aromatic hydrocarbons.

Domestic fuel burning shows a characteristic diurnal and seasonal signature. Periods of elevated domestic fuel burning, and hence emissions, occurs in the early morning and evening for heating and cooking purposes. During the winter months, an increase in domestic fuel burning is recorded as the demand for heating and cooking increases with the declining temperature.

Table 9: Household fuel usage in the West Coast District Municipality (% of households).

Fuel	Lighting	Cooking	Heating
Electricity	87.86	79.19	74.25
Gas	0.22	6.56	1.49
Paraffin	2.44	5.50	4.87
Candles	9.00	-	-
Wood	-	7.93	14.69
Coal	-	0.24	0.26
Animal dung	-	0.30	0.18
Solar	0.09	0.14	0.11
Other	0.37	0.14	4.15

The spatial distribution of wood and paraffin burning in the West Coast is shown in Figure 25. Domestic fuel burning occurs predominantly in high density informal settlements in and around major towns, as well as low-income areas in the District.



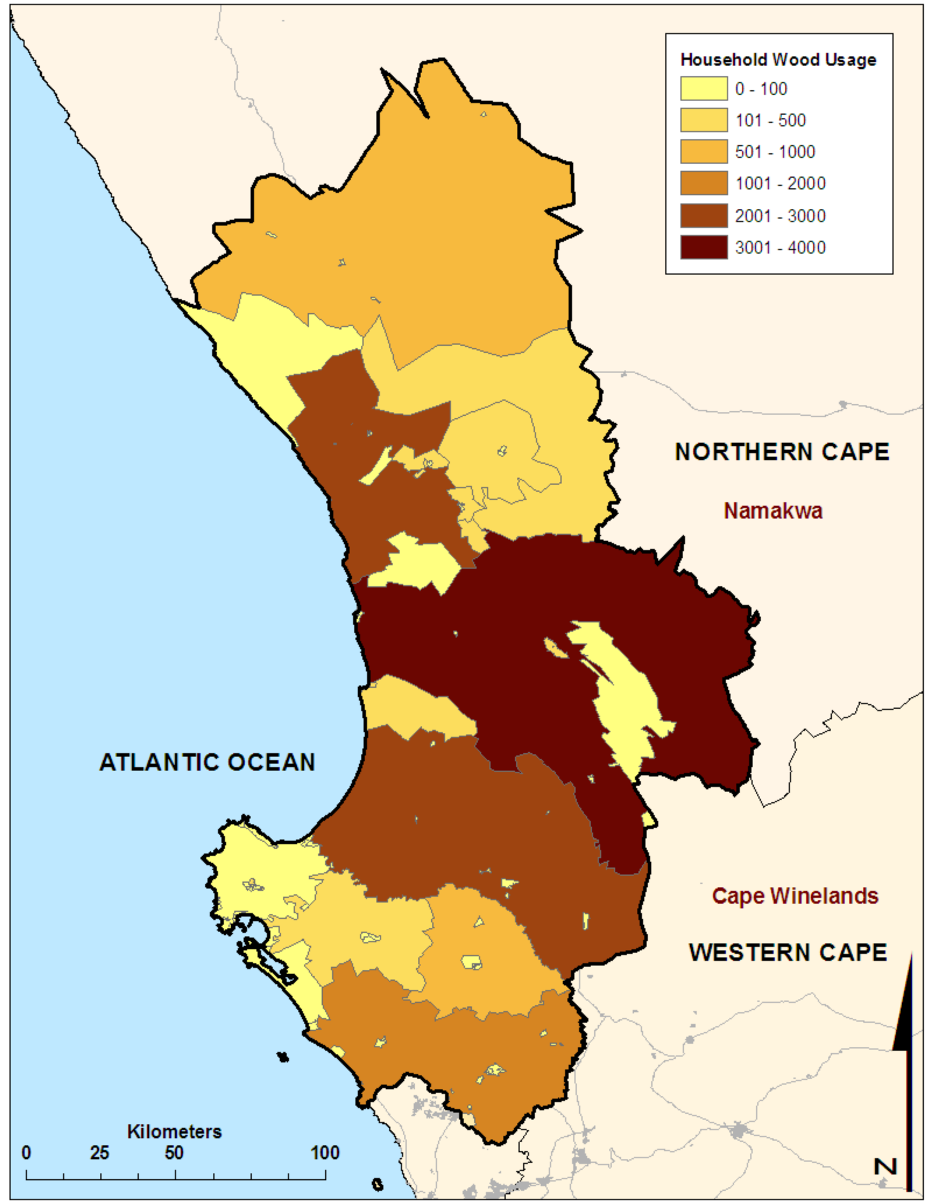


Figure 25: Household paraffin per ℓ (left) and wood in m^3 (right) usage in the West Coast District Municipality.

Information on the numbers and spatial distribution of households using domestic fuels for domestic purposes in the West Coast District was estimated based on fuel use statistics and household numbers from the Census 2001. Monthly fuel consumption figures for low-income households were used together with the numbers of households using the various fuel types to estimate the total quantities of fuels being consumed. The emission factors used to calculate domestic fuel burning emissions are given in Table 10.

Table 10: Emission factors for domestic fuel burning (Liebenberg-Enslin *et al*., 2007).

Fuel	Emission Factors		
	SO_2 (g/kg)	NO (g/kg)	PM10 (g/kg)
Coal	11.6[(a)]	4[(d)]	12[(f)]
Paraffin	0.1[(b)]	1.5[(e)]	0.2[(e)]
Wood	0.2[(c)]	1.3[(c)]	17.3[(c)]

(a) Based on sulphur content of 0.61% and assuming 95% of the sulphur is emitted. The lowest percentage sulphur content associated with coal used by local households was used due to previous over predictions of sulphur dioxide concentrations within residential coal burning areas. Previous predictions were significantly above measured sulphur dioxide concentrations. With the assumption of a sulphur content of 0.61%, predicted sulphur dioxide concentrations are slightly above, but within an order of magnitude, of measured concentrations.

(b) Based on sulphur content of paraffin (<0.01% Sulphur).

(c) Based on US-EPA emission factor for residential wood burning (EPA, 1996).

(d) Based on the Atomic Energy Corporation (AEC) household fuel burning monitoring campaign (Britton, 1998) which indicated that an average of 150 mg/MJ of NO_x were emitted during cooking and space heating. Given a calorific value of 27 Mj/kg, the emission rate was estimated to be ~4 g/kg.

(e) US-EPA emission factors for kerosene usage (EPA, 1996).

(f) Initially taken to be 6 g/kg based on 2001 synopsis of studies pertaining to emissions from household coal burning (Scorgie *et al*., 2001). Results from simulations using this emission factor undertaken as part of the current study indicated that fine particulate concentrations within household coal burning areas are under predicted by a factor of two. This emission factor was therefore scaled to 12 g/kg in order to facilitate the more accurate simulation of airborne fine particulates within household coal burning areas.

Estimated total domestic fuel burning emissions for the West Coast District are given in Figure 26. Matzikama and Cederberg are the largest contributors to domestic fuel burning emissions in the District, mainly due to the predominant use of wood in these areas. Saldanha Bay has the highest percentage of households using alternative fuel sources and however has the lowest emissions caused from domestic fuel burning after the DMA’s. This is most likely attributable to the fact that households in the Saldanha

Bay Local Municipality seem to prefer paraffin, which emits less pollution compared to wood and coal options.

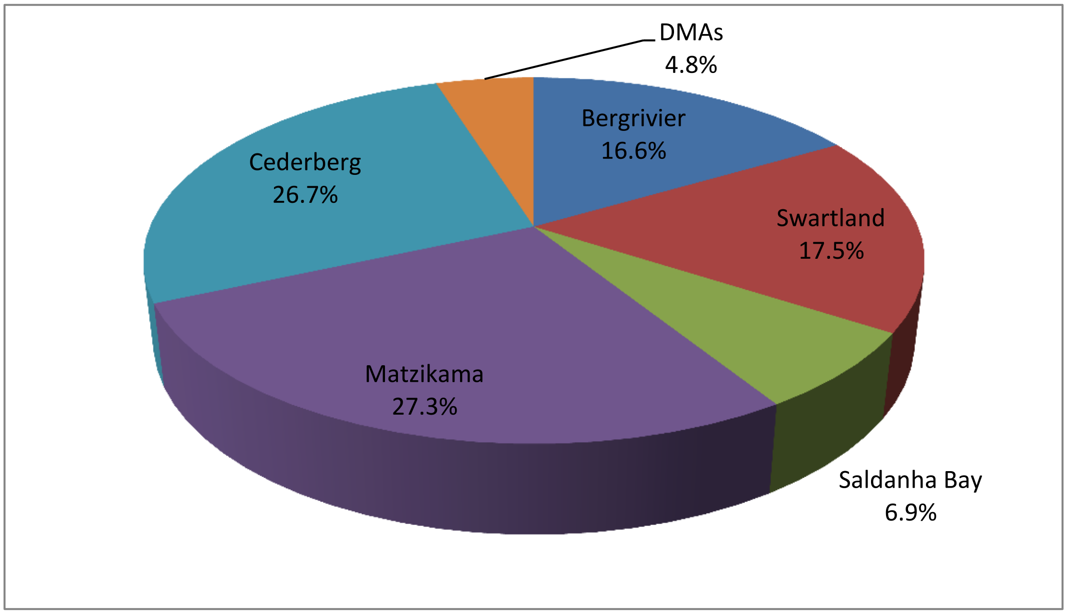


Figure 26: Estimated total domestic paraffin, wood and coal burning emissions in the West Coast District Municipality.

Emissions were calculated using information from the Census 2001 data. The more recent Community Survey 2007 records a decrease in the percentage of households using domestic fuels since 2001. However, this survey only provides information at the lowest level of Municipalities and cannot be used. An overestimation in current domestic fuel burning emissions is therefore possible.

6.2.3Mining activities

Mining activities also contribute to pollution in the West Coast. Pollution sources are mainly surface activities like waste loading and unloading, iron ore loading and unloading, screening plants, exposed waste dumps, stock yards, exposed pit surfaces, transport and haul roads. These all contribute to particulate matter concentrations. (Figure 21 and Figure 22).

6.2.4 ***Transportation***

6.2.4.1 Vehicle Emissions

One of the major contributors to urban air pollution is vehicular emissions. Atmospheric pollutants emitted from motor vehicles include hydrocarbons, CO, NO_x, SO_2 and particulates. Hydrocarbon emissions, such as benzene, result from the incomplete combustion of fuel molecules in the engine. CO is a product of incomplete combustion and occurs when carbon in the fuel is only partially oxidized to carbon dioxide. NO_x are formed by the reaction of nitrogen and oxygen under high pressure and temperature conditions in the engine. SO_2 is emitted due to the high sulphur content of the fuel. Particulates such as lead originate from the combustion process as well as from brake and clutch linings wear. With the introduction of unleaded fuel, lead emissions have been reduced. Diesel engines are a significant source of particulate emissions. Vehicle emission rates are affected by specific vehicle-related factors such as vehicle class, model, fuel-delivery system, vehicle speed and maintenance history; fuel-related factors such as fuel type, oxygen, sulphur, benzene and lead content and environmental factors such as altitude, humidity and temperature (Samaras and Sorensen, 1999).

The West Coast District road network is made up of National, Provincial and Local roads. The N7 National road runs from north to south in the West Coast District. Registered vehicle data for each Local Municipality was obtained from the District Municipality and is shown in Table 10. Swartland and Saldanha Bay Local Municipalities have the highest number of registered vehicles in the District. Vehicle count data within the District for 2009 was obtained from the South African Roads Agency and provided by Mikros Traffic Monitoring, however is limited to the N7 and therefore not representative of the region as a whole. Fuel sales per licensing district were obtained from the District Municipality and are given in Table 11.

Table 11: Registered Vehicles in the West Coast District as at 30 November 2009.

Vehicle Type	Cederberg	Swartland	Bergrivier	Saldanha Bay	Matzikama
HLV	761	2469	748	822	835
LLV	3801	9857	5538	9385	5532
HPV	32	63	52	111	63
LPV	3286	14105	6217	14404	4948
MB	113	444	164	449	152
MC	316	1201	558	1453	533
SV	1543	3390	1768	1081	1645
Un	27	53	60	55	47
Total	**9879**	**31582**	**15105**	**27760**	**13755**

HLV – Heavy Load Vehicle (>3500kg)
LLV – Light Load Vehicle (< 3500 kg)
HPV – Heavy Passenger Vehicle (12 or more persons)
LPV – Light Passenger Vehicle (less than 12 persons)
MB – Minibus
MC – Motorcycles
SV – Special Vehicles
Un – Unknown

Table 12: Fuel sales per licensing district within the West Coast District for January – December 2008.

Local Municipality	Licensing District	Petrol (litres)	Diesel (litres)
Cederberg	Clanwilliam	6 844 686	13 105 991
Swartland	Malmesbury	31 735 213	139 858 535
Swartland	Moorreesburg	3 810 688	23 612 388
Bergrivier	Piketberg	11 070 287	10 999 782
Saldanha Bay	Vredenburg	29 548 145	43 319 016
Matzikama	Vredendal	8 069 078	14 381 432

Table 13: Coastal emission factors for petrol vehicles (Wong and Dutkiewicz, 1998).

Pollutant	Petrol (g/km)
NO_x	2.84
CO	16.4
CO_2	213
SO_2	0.091
Total HCs	1.98
Methane	0.055
Benzene	0.036
1,3 Butadiene	0.022
Formaldehyde	0.0104
Acetaldehyde	0.0046
Total Aldehydes	0.015
Particulates	0.000

Table 14: Coastal emission factors for diesel vehicles (Stone, 2000).

Pollutant	Light Commercial Vehicles (g/km)	Medium & Heavy Commercial Vehicles (g/km)
NO_x	1.82	11.68
CO	1.13	3.54
CO_2	245	739
SO_2	0.796	1.54
Total HCs	0.2	1.01
Methane	0.007	0.088
Benzene	0.002	0.000
1,3 Butadiene	0.003	0.004
Formaldehyde	0.0102	0.016
Acetaldehyde	0.0109	0.010
Total Aldehydes	0.021	-
Particulates	0.293	0.64

Total vehicle emissions for the West Coast District Municipality is calculated using traffic count data, however available data are restricted to the N7 and therefore cannot be used, for it is not representative of vehicle emissions within each Local Municipality. Thus fuel sales data/figures within each Local Municipality have been used. For simplicity it is assumed that petrol sales are for light vehicles (i.e. light passenger

vehicles) and diesel sales are for heavy vehicles (i.e. heavy load vehicles). Based on studies done by Vanderschuren and Jobanputra (2005), and Mårtensson (2003), fuel consumption rates for petrol (light passenger vehicles) and diesel (heavy load vehicles) can be averaged at 9l/100km and 30l/100km respectively. Results are shown in Figure 27.

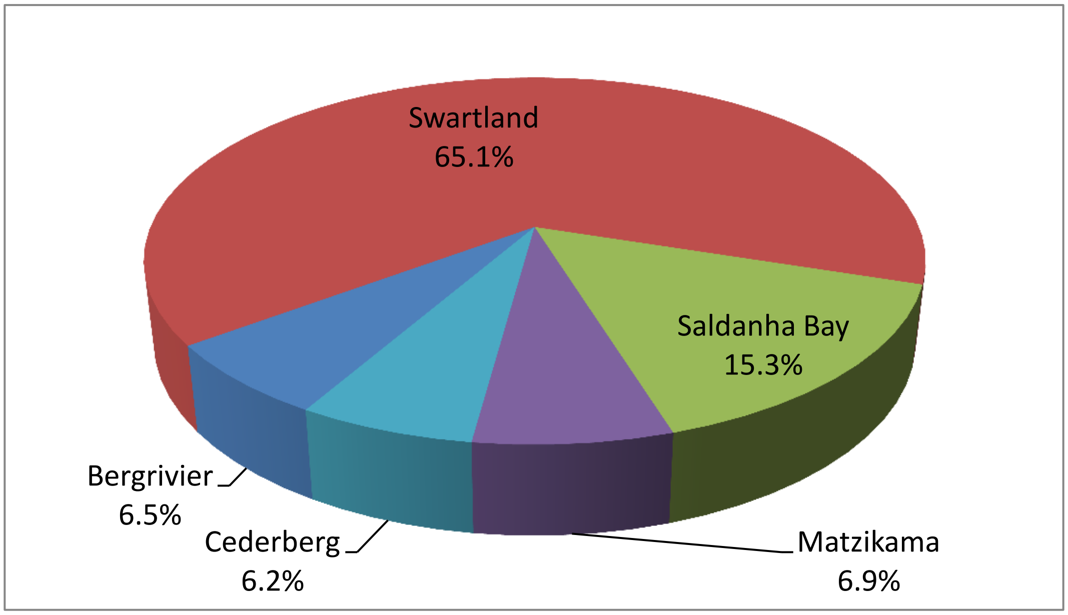


Figure 27: Estimated total vehicle emissions in the West Coast District Municipality.

6.2.4.2 Airports

Airports contribute greatly to air pollution due to airport operations, vehicle traffic, on-site fuel storage facilities and aircraft maintenance and operation. On a local level, commercial aircraft are a significant contributor to urban air pollution. Airports produce large amounts of air pollution, emitted from aircraft operations, ground service equipment, vehicular activity (motor vehicles, taxis and busses), fuelling facilities and other stationary sources such as airport power sources. Air pollution sources from airport activities can be categorised into the following (Dracoulides, 2002) -

- Aircraft activities (taxi in and out, runway queue, aircraft takeoff and climb-out,, aircraft approach and landing, aircraft parking and routine engine testing)
- Ground support equipment and auxiliary power units while the aircraft is parked at the gates,

- Vehicular activities (traffic within and around the airport, parking lots),
- On-site fuel storage tanks and emissions from emergency power generators.

Aircraft engines produce CO_2, H_2O, NO_x, CO, SO_x, VOCs, particulates and other trace elements. About 10% of all aircraft emissions, except hydrocarbons and CO, are produced during ground level activities and during landing and takeoff. The majority of aviation emissions (90%) occur at higher altitudes (FAA, 2005).

Emission factors have been developed for the estimation of gaseous emissions from aircraft engines. Emission factors are available for different aircraft types, which can have several different engine combinations. These factors are provided in kg of pollutant per landing-takeoff cycle and in kg of pollutant per ton of fuel used to calculate landing-takeoff emissions and cruise emissions, respectively. Emissions generated by the ground support equipment, generators and auxiliary power units can also be estimated. Stationary sources, such as power and heating plants, fuel storage tanks and incinerators can be calculated using emission factors from the USEPA AP-42 database (Dracoulides, 2002).

Information required to estimate emissions from airports includes an inventory of aircraft types, average durations of taxi in and out operations, frequency of landings and take-offs, auxiliary power units operation, amount of fuel burned etc.

Several airfields are situated in the West Coast District and are located at Clanwilliam, Citrusdal, Vredendal, Lamberts Bay, Langebaan Road, Vredenburg/Saldanha and Malmesbury as well as various crop-spraying runways. The runway at Langebaan Road is used for airforce purposes, while the airport at Vredenburg/Saldanha is the largest. These airports provide for the landing of small aircraft to the District. Emissions from these airports are considered to be insignificant and are therefore not quantified as part of this plan.

6.2.4.3 Harbours

Ports can be a major contributor to poor air quality, mostly due to emissions from high shipping volumes and vehicle activities within and around the harbour. The port of Saldanha Bay is South Africa's largest natural anchorage and port northwest of Cape Town. The port was developed into a modern harbour recently to facilitate iron ore

exports from the Northern Cape. It is equipped with an Iron-Ore Terminal and a Multi-Purpose Terminal. According to the Transnet National Ports Authority (www.transnet.co.za), Saldanha Bay handles approximately 400 ships per year which amounts to 3% of South Africa's total vessel arrivals making it one of the least busy ports in the country. Therefore emissions from the port are considered to be insignificant for the District as a whole and thus have not been quantified as part of the plan.

6.2.5 *Agriculture*

Agriculture is a dominant land-use within many areas of the West Coast District. Wheat, citrus, potato, rooibos tea, wine and deciduous fruit farming have been identified to occur in the area.

Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions (USEPA, 1995). Expected emission resulting from agricultural activities include particulates associated with wind erosion and burning of crop residue, chemicals associated with crop spraying and odiferous emissions resulting from manure, fertilizer and crop residue.

Dust associated with agricultural practices may contain seeds, pollen and plant tissue, as well as agrochemicals, such as pesticides. The application of pesticides during temperature inversions increases the drift of the spray and the area of impact. Dust entrainment from vehicles travelling on gravel roads may also cause increased particulates in an area. Dust from traffic on gravel roads increases with higher vehicle speeds, more vehicles and lower moisture conditions.

Air emissions from pesticides arise because of the volatile nature of many active ingredients, solvents, and other additives used in formulations, and of the dusty nature of some formulations. Most modern pesticides are organic compounds. Emissions can result directly during application or as the active ingredient or solvent volatilizes over time from soil and vegetation. Organic compounds and particulate matter are the main air emissions from pesticide application. The active ingredients of most types of synthetic pesticides used in agriculture have some degree of volatility, ranging from non-volatile, semi-volatile to volatile organic compounds (e.g. fumigants). Many pesticide formulations are liquids or emulsifiable concentrations which contain volatile organic solvents such as xylene, emulsifiers, diluents and other organics.

The quantity of agrochemicals consumed in the District could not be obtained due to the sensitive nature of this information, and therefore the impact of this source on the air quality in the District could not be determined.

6.2.6 Biomass Burning

Biomass burning emissions constitute a significant proportion of the aerosols and trace gases present in the prevalent haze layer found over southern Africa (Li *et al*., 2003). In southern Africa, fires are mostly lit by people for land management or by lightning (Roy *et al.*, 2005). In the southern African region, fire is the dominant, process, producing hydrocarbons and aerosols (Swap *et al*., 2003) and burning is a significant source of greenhouse gases, especially CO_2 and methane (CH_4), and photochemical gases (NO_x, CO and hydrocarbons) that lead to the production of tropospheric ozone (O_3) (Levine *et al.*, 1996; Piketh and Walton, 2004).

The properties of emissions are directly related to the type of burning process, fuel type and age of the smoke (Li *et al*., 2003). Smouldering fires (less efficient) have less complete combustion and release more CO, whereas, flaming (intense, efficient) fires have more complete combustion and release more CO_2 (Ward *et al*., 1996; Scholes *et al*., 1996). A flaming fire, due to the lack of oxygen, will lead to the formation of soot, which due to its absorbing properties may disturb the regional vertical temperature profile (Ross *et al*., 1998). Flaming combustion usually dominates in the early burn of savannah and scrubland where emissions such as NO_x are favoured over CO or CH_4 (Barbosa *et al*., 1999). This is followed by a smouldering stage that can continue for a number of days or possibly weeks (Edwards *et al*., 2006). Fully oxidised products such as CO_2 and NO_x usually result from the combustion of grasslands, whereas the smouldering nature of leaf litter and twigs in woodland beds generate more products of incomplete combustion (Korontzi *et al*., 2004). The West Coast region falls within the Cape Floral Kingdom and various biomes including Fynbos and Succulent Karoo.

Fire is less common in arid regions in the west and south-west interior of southern Africa, as there is insufficient available biomass fuel (e.g. dead wood, grass, shrubs and litter) (Roy *et al.,* 2005). South Africa has a complex relationship between fire incidence and rainfall. This is a consequence of winter rainfall and summer/autumn burning on the

south west coast and summer rainfall and winter/spring burning over the rest of the country. In general, there is an inverse relationship between fire incidence and rainfall, i.e. burning occurs mainly during the dry season. The emissions released due to burning can be calculated by using active fire detection as a proxy for burning and applying emissions factors for relevant vegetation types.

Kruger *et al*., 2006 developed a classification of veld fire risk for Municipalities in South Africa based on the prevailing vegetation type. Areas of extreme risk occur mainly within the savannah and grassland biomes while areas of high risk occur in the savannah and fynbos biomes. The West Coast District Municipality falls within the Succulent Karoo and Fynbos biome (Figure 28), the veld fire risk has been classified as low for Matzikama, medium for Saldanha Bay and Swartland and high for Bergrivier and Cederberg Local Municipalities (Figure 29).

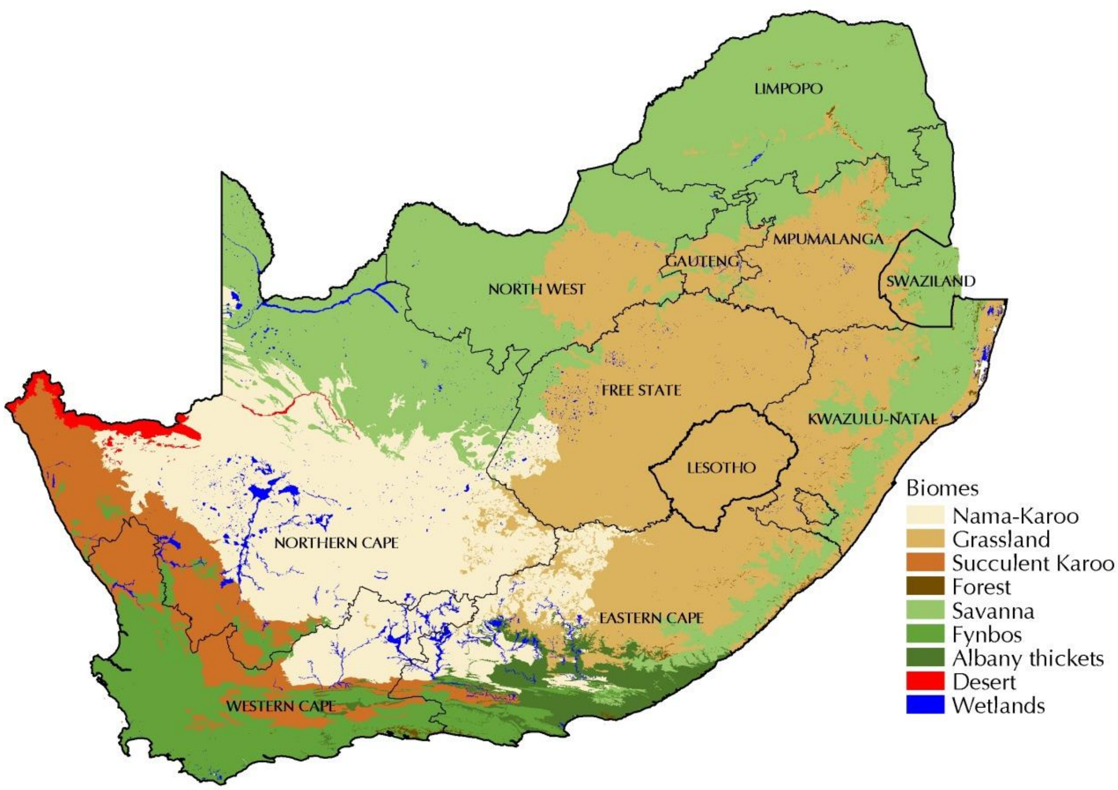


Figure 28: Biomes of South Africa (National Spatial Biodiversity Assessment, 2004).

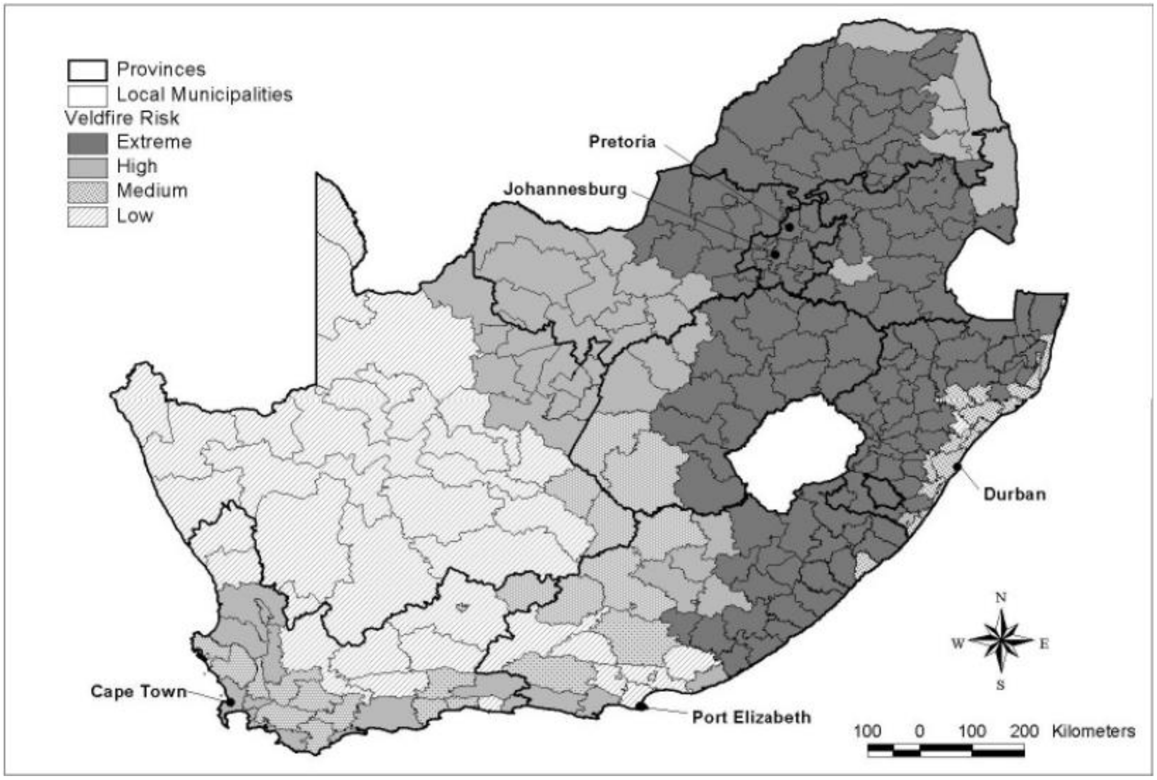


Figure 29: **South African Municipalities classified according to four levels of veld fire risk (Kruger et al., 2006).**

Burned areas for the West Coast District are approximated by assuming each fire is 1 km × 1 km (Table 15). The spatial distribution of fires in the West Coast District is shown for the period 2004 – 2007 in Figure 30. As a whole biomass burning has a moderate frequency of occurrence in the District, with most incidences limited to the southern half of the region.

Table 15: **Burned area using number of detected fires as a proxy.**

Period	Burned area (km^2)
2004	517
2005	670
2006	761
2007	665

6.2.6.1 Moderate Resolution Imagine Spectroradiometer

Moderate Resolution Imaging Spectroradiometer (MODIS) was launched by National Aeronautics and Space Administration (NASA) on the polar orbiting Earth Observation System (EOS) (Kaufman *et al*., 1998). MODIS Data are calibrated and processed using cloud screening, geo-location and atmospheric correction and is available on the World Wide Web (http://modis-atmos.gsfc.nasa.gov) (Roy *et al*., 2005a). MODIS on the TERRA spacecraft offers daily global coverage in 36 reflectance and thermal infrared spectral bands at a resolution of 1 km or better (Moeller *et al*., 2003). MODIS has the ability to detect sub-pixel (smaller) fires, which will provide a greater understanding of the extent of human influence on fires (Hély *et al.*, 2003). The MODIS fire algorithm works via a number of threshold tests carried out on the potentially active fire using the brightness temperature from the 4 μm channel, as well as the difference in brightness temperatures of the 4 μm and 11 μm channels to differentiate the fire pixel from the non-fire background. Additional specialised tests are applied to the data to eliminate false detections that can be attributed to sun glint, desert boundaries and errors in the water mask. At the end of the process, pixels are assigned to a class as missing data, clouds, water, non-fire, fire or unknown (Morisette *et al*., 2005). MODIS active fire data are used as an input into the AFIS project.

6.2.6.2 Fire detection via satellite in South Africa

The Council for Scientific and Industrial Research (CSIR) Satellite Applications Centre (SAC) in conjunction with Eskom and the Department of Agriculture has developed a fire monitoring system, the Advanced Fire Information System (AFIS). The AFIS product has been developed with the assistance of the NASA and the University of Maryland and uses MODIS and MSG data, and applies the Wild Fire Automated Biomass Burning Algorithm (WF_ABBA) to the satellite data. This near-real time monitoring system provides fire information to disaster management centres, fire protection agencies, Eskom's national control centre and researchers, in an attempt to document and monitor the frequency and distribution of natural and man-made fires and allow for early fire detection. The products generated are displayed as regional maps and are accessible on the internet (www.wamis.co.za/eskom/checkboxes/eskom.htm). The fire products used in this project were obtained from the CSIR SAC and are results from the AFIS project.

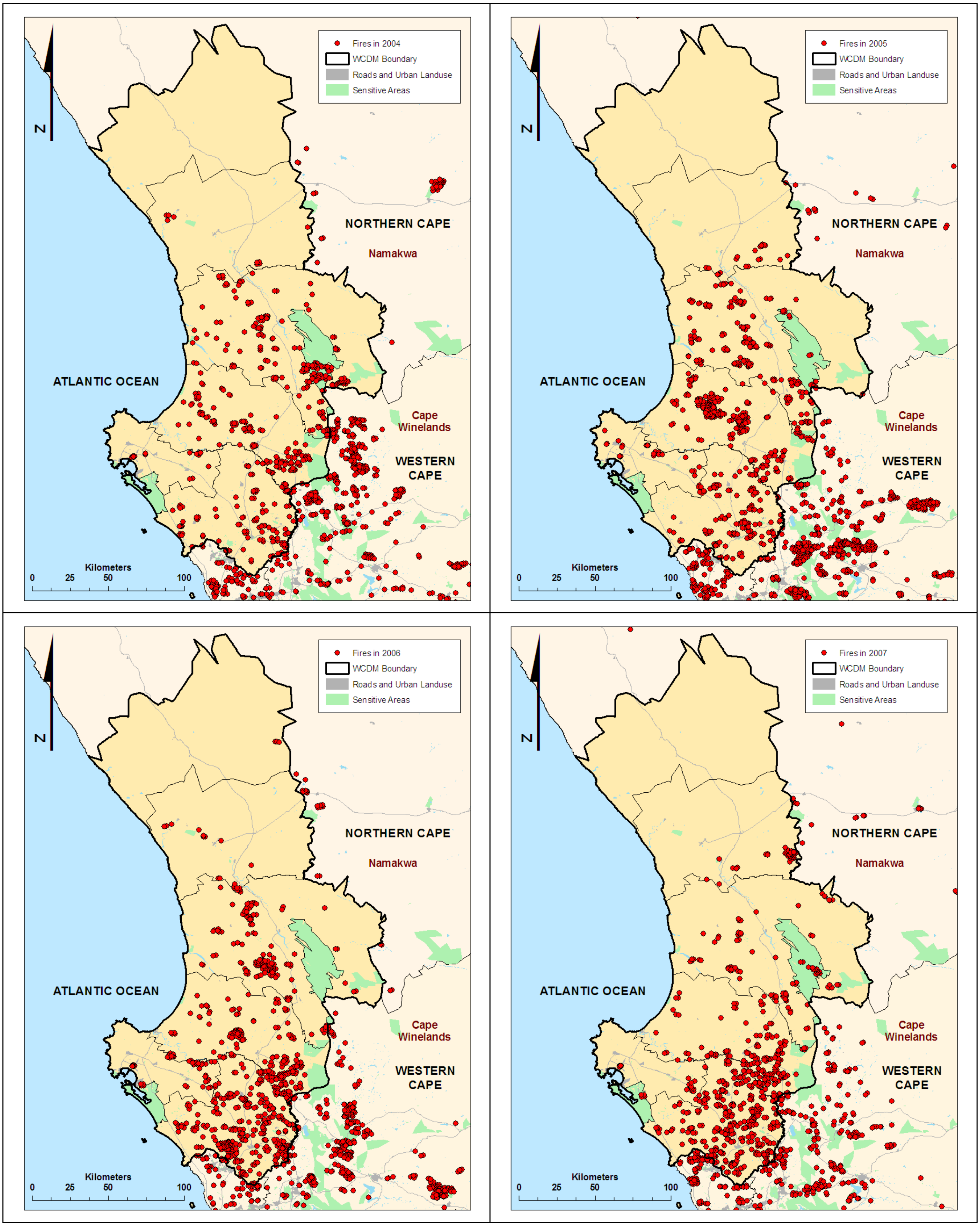


Figure 30: **Spatial distribution of fires in the West Coast District Municipality for 2004 (top left), 2005, (top right), 2006 (bottom left) and 2007 (bottom right).**

Currently the District does not have a By-law governing burning in the region; however the National Veld and Forest Fire Act (No. 101 of 1998) regulations are currently being followed. The District Municipality is responsible for issuing burning permits and during the period January 2009 – May 2010, 211 permits were issued for controlled burning.

Unauthorised burning does take place in the District as communities are not accustomed to or aware they are required to hold a permit to burn. Over the last few years controlled burns have been restricted due to the high fire danger. As a result the District has a large build-up of fire load. Plans are being made to start block burning and create fire breaks to reduce the risk of runaway fires.

Seasonal restrictions (November to April) are issued by the minister for certain parts of the Western Cape, which are also applied by the West Coast District. Under certain circumstances burning permits are issued for prescribed or controlled burning during this period; however this mostly applies to wheat farmers who need to burn their land in preparation for the planting season.

Before permits are issued the property is inspected to ensure all laws and regulations are adhered to and the owner has sufficient resources to control the fire. Once the permit has been issued the permit holder is still required to contact the municipality for permission to burn on a particular day. f the Fire Danger Index rating for that day is too high the permit holder will not be allowed to burn, (pers. comm., B, Senekal, Chief Fire Officer, West Coast District Municipality).

6.2.7 Waste Treatment and Disposal

Waste treatment and disposal methods which are of interest in terms of the toxicity and odiferous nature of their emissions include: incineration, landfills and waste water ponds used for the treatment, storage and disposal of liquid wastes.

6.2.7.1 Landfills

Emissions from landfills are a concern in terms of the potential for health effects and the odours generated. Landfills are important sources of the greenhouse gases such as CH_4 and CO_2, which account for approximately 40 – 60% of all landfill emissions. Landfill gases also contain trace amounts of non-methane organic compounds, including

various hazardous air pollutants and VOCs (USEPA, 1995). Odorous emissions from landfills can also be a severe public nuisance.

Based on air quality impact assessments conducted for general and hazardous waste disposal sites, Liebenberg-Enslin and Petzer (2005), found that within 500 m of the landfill severe health effects occur, odour is potentially an issue between 200 m and 5 km depending on the management of the facility and nuisance dust impacts are usually restricted to the landfill boundary.

In terms of the Environment Conservation Act No 73 of 1989, all landfill sites must obtain a disposal site permit before such sites are established or operated. The Department of Water Affairs and Forestry (DWAF) was previously responsible for the issuing of these permits. With the transfer of the permitting function from DWAF to DEA, the DEA have initiated the Waste Disposal Site Permitting Backlog Project to address the backlog in landfill permits.

Information on the exact number and status of landfill sites within the West Coast District could not be obtained by the time this study was concluded. Information received on landfill sites within the Saldanha Bay Local Municipality is shown in Table 16.

Table 16: Waste Disposal Facilities in the West Coast District Municipality.

Local Municipality	Landfill Site	Life Span (years)	Classification
Saldanha Bay	Vredenburg	25	GMB-
	Langebaan	20	GSB-
	Saldanha Steel	Not Known	GLB+
	Langebaan garden/building rubble facility	20	GMB-
Matzikama	Klawer	Not Known	Not Known
	Nuwerus	Not Known	Not Known
	Doringbaai	Not Known	Not Known
	Ebeneser	Not Known	Not Known
	Vredendal	Not Known	Not Known
	Van Rhynsdorp	Not Known	GSB-
	Lutzville	Not Known	Not Known
	Standfontein	Not Known	Not Known
Cederberg	Wuppertal	Not Known	Not Known
	Elandsbaai	< 5	Not Known
	Citrusdal	< 5	GSB+
	Clanwilliam	< 1	Not Known
	Graafwater	< 7	Not Known
	Lamberts Bay	< 5	Not Known
Bergrivier	Piketberg	Not Known	Not Known
	Porterville	Not Known	Not Known
	Velddrift	Not Known	Not Known
	Aurora	Not Known	Not Known
	Redelinghuys	Not Known	Not Known
Swartland	Klipkop	31	GCB-
	Darling	Not Known	GCB-
	Moorreesburg	Not Known	Not Known
	Koringberg	Not Known	Not Known
	Malmesbury	Not Known	Not Known
DMA	Bitterfontein	Not Known	Not Known

6.2.7.2 Incinerators

Waste incineration processes (Scheduled Process 39) are processes for the destruction by incineration of waste that contains chemically bonded halogens, nitrogen, phosphorous, sulphur or metal, or any waste that can give rise to noxious or offensive gases. Incinerators are classified into various classes, whereby Class 1 incinerators are incinerators in which the waste serves as the fuel or supplementary fuel in an industrial process (e.g. use of cement kilns for the disposal of waste), Class 2 incinerators are

used for the disposal of hazardous or potentially hazardous waste and medical waste and Class 3 incinerators are used for the disposal of general waste.

Since March 1998, Environmental Impact Assessments have been required for proposed incinerator operations. The Department of Environmental Affairs is in the process of introducing air emission standards for the treatment of hazardous waste and co-processing of alternative fuels and raw materials in cement kilns.

Pollutants released from waste incineration include sulphur dioxide, heavy metals, acid gases, dioxins and furans, which represent a considerable air quality and human health risk. Particulate emissions from incinerators may also contain heavy metals such as chromium and cadmium, which are suspected human carcinogens.

Information on incinerator operations within the West Coast is limited, although incineration is likely to occur on a small-scale within the District. Clanwilliam Hospital and Radie Kotze Hospital have discontinued the use of their incinerators. Swartland Hospital, Vredenburg Hospital, Vredendal Hospital and Citrusdal Hospital have been known to operate incinerators although their current status is unknown. In most instances health care waste from Provincial and private hospitals are being removed by registered service providers and incineration has been phased out at these facilities.

6.2.7.3 Waste Water Treatment Works

Pollutants released during waste water treatment include a range of Volatile Organic Compounds. Species measured at local waste water treatment works include hydrogen sulphide, mercaptans, ammonia, formaldehyde, acetone, toluene, ethyl benzene, xylenes, perchloroethylene, butyric acid, propionic acid, valeric acid and acetic acid. Waste water treatment works also have the potential to generate unpleasant odours, which can result in annoyance and consequently have a detrimental effect on a local population. Species associated with odours include hydrogen sulphide and ammonia as well as a variety of organic sulphides and organic nitrogen based compounds along with some oxygenated organic compounds and organic acids.

According to the Constitution, the Municipal Structures and the Water Services Act of 1997, responsibility for the provision of water and sanitation lies with the District Municipalities. Operational treatment facilities within the West Coast District are shown

in Table17 below. The status of these facilities is unknown and therefore has not been quantified in this study.

Table 17: Waste water treatment works in West Coast District Municipality.

Municipality	Sewerage Works	Managed by
Bergrivier	Porterville	Municipality
	Piketberg	Municipality
	Velddrif	Municipality
	PPC De Hoek	Private
	Dwarskersbos	Municipality
	Redelinghuys	Municipality
	Eendekuil	Municipality
Cederberg	Clanwilliam	Municipality
	Graafwater	Municipality
	Lambertsbaai	Municipality
	Elandsbaai	Municipality
	Citrusdal	Municipality
	Wupperthal	Municipality
DMA	Algeria Bosb.stasie	District
	Rietpoort	District
	Bitterfontein	District
	Nuwerus	District
Matzikama	Lutzville	Municipality
	Lutzville-Wes	Municipality
	Koekenaap	Municipality
	Ebenhaezer	Municipality
	Doringbaai	Municipality
	Strandfontein	Municipality
	Vredendal-Suid	Municipality
	Verdendal-Noord	Municipality
	Klawer	Municipality
	Vanrhynsdorp	Municipality
Saldanha Bay	Langebaan	Municipality
	Saldanhabaai	Municipality
	Vredenburg	Municipality
	St Helenabaai	Municipality
	Shelly Point	Municipality
	Hopefield	Municipality
	Paternoster	Municipality
Swartland	Malmesbury	Municipality
	Darling	Municipality
	Koringberg	Municipality
	Riebeeck-Wes	Municipality
	Riebeeck- Kasteel	Municipality
	Moorreesburg	Municipality
	Chatsworth	Municipality
	Kalbaskraal	Municipality
	Broodkraal	Private
	Elanie Oord	Private
	PPC Riebeeck-Wes	Private

6.2.8 Other Sources

Other sources of air pollution in the District could include tyre burning and informal refuse burning. Tyre burning occurs to remove the copper from the tyres as well as for heating purposes. Detailed information on tyre burning in the District could not be

obtained. Informal burning also takes place within informal settlements which contributes significantly to ambient particulate concentrations which is discussed in this report.

6.2.9 Trans boundary Transport of Air Pollution

One of the single challenges facing authorities responsible for addressing air quality issues in their respective regions is the transport of pollutants from beyond their border of control. Bordering the West Coast District is the City of Cape Town Metropolitan Municipality, which frequently experiences elevated pollution levels, and the Cape Winelands District Municipality, where seasonal biomass burning occurs. The spatial distribution of fires in and surrounding the West Coast District is shown in Figure 30. The trans boundary transport of emissions from these areas has implications for the current air quality situation in the West Coast District.

6.2.10 Summary of Air Pollution Sources in the District

The main air pollution sources in the District Municipality have been identified and where possible, quantified. A summary of the air pollution sources and their emission are provided in Table 18.

Table 18: Summary of air pollution sources and their associated emissions in the West Coast District.

Sector	Source	Description	PM10	SO_2	NO_2	Other
Abbatoirs	Darling Hoeder Abattoir	Abattoir	✓	✓	✓	✓
	Swartland Afvalprodukte	Abattoir	✓	✓	✓	✓
Animal Matter Reduction Processes	AquaNutro	Animal feed production	✓	✓	✓	✓
	Hannasbaai Fishing Company	Fish species procurement/processing/canning	✓	✓	✓	✓
	La Vie Seafood Products	Fish species procurement/processing/canning	✓	✓	✓	✓
	Marine Products	Fish species procurement/processing/canning	✓	✓	✓	✓
	Oceana	Fish species procurement/processing/canning	✓	✓	✓	✓
	Petfood Caterers	Animal feed production	✓	✓	✓	✓
	Pioneer Foods: Nova Voere	Animal feed production	✓	✓	✓	✓
	Pioneer Oranjevis	Fish species procurement/processing/canning	✓	✓	✓	✓
	West Point Processors	Fish species procurement/processing/canning	✓	✓	✓	✓
Agriculture	Bergrivier, Cederberg, Matzikama and Swartland	Wheat, Citrus, Potato, Rooibos tea, Grapes and Deciduous fruit	✓			✓
Biomass Burning		Agricultural burning and veld fires (controlled and uncontrolled)	✓	✓	✓	✓
Brickworks	J&J Brickworks	Brick manufacturing	✓	✓	✓	
	Namakwa Stene	Brick manufacturing	✓	✓	✓	
	Van Dyk Precast	Brick manufacturing	✓	✓	✓	
Cement Processes	Pretoria Portland Cement (De Hoek)	Cement manufacturing	✓	✓	✓	✓
	Pretoria Portland Cement (Riebeek West)	Cement manufacturing	✓	✓	✓	✓
Domestic Fuel Burning	Bergrivier, Cederberg, Matzikama, Swartland and Saldanha Bay	Paraffin and wood burning in informal settlements	✓	✓	✓	✓
Hospitals	Citrusdal Hospital	Hospital	✓	✓	✓	✓
	Clanwilliam Hospital	Hospital	✓	✓	✓	✓
	Swartland Hospital	Hospital	✓	✓	✓	✓
	Vredenburg Hospital	Hospital	✓	✓	✓	✓
	Vredendal Hospital	Hospital	✓	✓	✓	✓
Landfills	Langebaan	General waste disposal	✓	✓	✓	✓
	Vredenburg	General waste disposal	✓	✓	✓	✓
Mining	Exxaro TSA Sands	Mineral sand seperation	✓			
	Trans Hex Mynbou Beperk	Diamond mining	✓			
Small Industries/Other	Bokomo Sugar Bird	Glacé fruit manufacturer	✓	✓	✓	
	Bonwit	Clothing manufacturing	✓	✓	✓	
	Ceder Pack	Packaging	✓	✓	✓	
	Citrus Juices		✓	✓	✓	
	Darling Dairy	Dairy production	✓	✓	✓	
	Goeie Hoop Citrus	Citrus packaging	✓	✓	✓	
	International Wire Distributors		✓	✓	✓	
	Khoisan Tea	Rooibos tea processing and packaging	✓	✓	✓	
	Koelby	Bottling plant	✓	✓	✓	
	McMillan Brick Sand		✓	✓	✓	
	Mortar SA	Mortar dry mix	✓	✓	✓	
	Noordwest Steengrowe		✓	✓	✓	
	Norsenet	Net manufacturing	✓	✓	✓	
	Nu Season		✓	✓	✓	
	Pioneer Foods: Sasko Pasta	Pasta Product manufacturing	✓	✓	✓	
	Red T Company	Rooibos tea processing and packaging	✓	✓	✓	
	Roelcor Vleis	Meat packaging and distribution	✓	✓	✓	
	Swartland Boudienste	Wood drying	✓	✓	✓	
	Swartland Winery	Wine distilling	✓	✓	✓	
	Titan Lime Company		✓	✓	✓	
Steel Processing	Arcelormittal	Steel production processing	✓	✓	✓	✓
	Duferco	Steel production processing	✓	✓	✓	✓
	Exxaro Namakwa Sands	Steel production processing	✓	✓	✓	✓
Trans-boundary Transport	Neighbouring Municipalities	Biomass burning and industrial emissions will impact the West Coast at particular times of the year	✓	✓	✓	✓
Tyre Burning	Bergrivier, Cederberg, Matzikama, Swartland and Saldanha Bay	Illegal tyre burning for extracting copper and for space heating purposes	✓	✓	✓	✓
Vehicle Entrainment on Unpaved Roads	Bergrivier, Cederberg, Matzikama, Swartland and Saldanha Bay	Dust emissions from vehicle activity on dirt roads	✓			
Vehicle Tailpipe Emissions	Bergrivier, Cederberg, Matzikama, Swartland and Saldanha Bay	Emissions from vehicle petrol and diesel consumption	✓	✓	✓	✓
Wind-blown Dust	Bergrivier, Cederberg, Matzikama, Swartland and Saldanha Bay	Wind erosion of exposed, open areas in the District.	✓			

6.3 Predicted Ambient Air Quality in the West Coast District

6.3.1 Dispersion Model Overview

Dispersion models are used to predict the ambient concentration in air of pollutants emitted to the atmosphere from a variety of processes (SANS 1929, 2005).

ADMS 4 is a PC-based, Gaussian plume dispersion model developed by Cambridge Environmental Research Consultants. ADMS 4 is a new generation air dispersion model, which is characterised by two main features:

- The atmospheric boundary layer properties are described using two parameters: the boundary layer depth and the Monin-Obukhov length.
- Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution.

ADMS 4 is designed with specific reference to industrial applications. Applications include odour modelling, environmental impact assessment and risk assessment. ADMS 4 can model 100 sources. A meteorological pre-processor calculates the required boundary layer parameters from input data which includes wind speed, day, time, cloud cover or wind speed, surface heat flux and boundary layer height. Meteorological data may be raw, hourly averaged or statistically analysed data. ADMS 4 uses the complex terrain model, FLOWSTAR to calculate the flow and turbulence fields that are then used to enhance the calculation of dispersion.

ADMS 4 can also be used to model the rate of dry and wet deposition to the ground, odours, plume visibility, radioactivity and chemical reactions between NO_x and O_3. The model is applicable up to 60km downwind of the source and provides useful information for distances up to 100km.

6.3.2 Model Requirements

Data input into the model includes hourly meteorological data which includes wind speed, wind direction, temperature, relative humidity, cloud cover and precipitation for. Meteorological data from ARC's Koperfontein station was used for modelling purposes due to the location of the station. Dispersion simulations of the criteria pollutants, PM10, SO_2 and NO_2, were undertaken to determine the predicted concentrations associated with industry in the Saldanha Bay and Swartland Local Municipalities. Comparison of the predicted concentrations was made with the relevant ambient air quality standards.

6.3.3 Dispersion Simulations

Isopleth plots of modelled NO_2, SO_2 and PM_{10} concentrations are provided below (Figures 27 - 29). The average stack height ranges between 20 m and 30 m which are considered to be relatively low. Emissions from low stacks tend to be localised and are not transported significant distances from the point of emission. The pollutant concentration plots show that maximum concentrations are recorded in close proximity to industry. Residential areas located within close proximity could potentially be affected by particulate and gaseous emissions. Concentrations are however low and therefore the health impact is negligible.

Predicted maximum hourly NO_2 concentrations of 0.48 µg/m^3 are below the hourly National standard limit value (hourly average National standard of 200 µg/m^3). No daily average NO_2 standard has been established for comparison with the predicted daily average concentration of 0.44 µg/m^3 (Figure 31). Maximum hourly (0.09 µg/m^3) and daily (0.12 µg/m^3) SO_2 concentrations were also found to be well below the National standard limits of 350 µg/m^3 and 125 µg/m^3 respectively (Figures 32). Maximum daily average PM10 concentrations of 0.32 µg/m^3 also fall well below the National Standard limit of 75 µg/m3 (Figure 33). All pollutant predictions also fall below the standards set by the City of Cape Town and none of the criteria pollutants present a health risk to the surrounding communities. Modelled pollution concentrations are extremely low as a result of emission reduction technology that most industries operating listed activities have installed. The model has excluded domestic fuel burning emissions and vehicle tailpipe emissions due to insufficient emissions data. Only industries who responded to the request for information have been quantified. Therefore it is likely that predicted emissions are underestimated. Monitoring data show predictions that are well below the National Standards and although there is a possibility that the predicted emissions are underestimated it would still not exceed the National Standards.

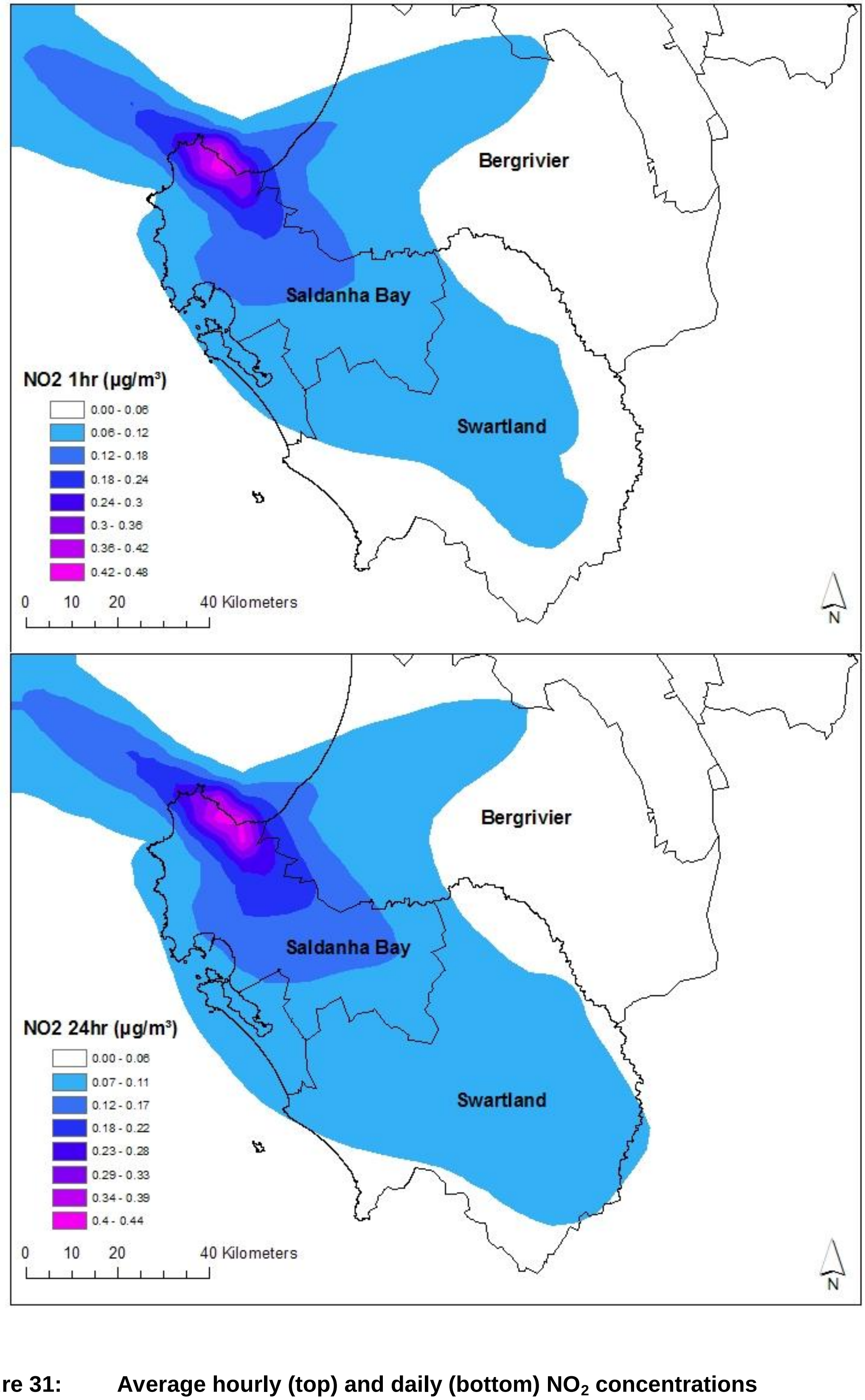


Figure 31: Average hourly (top) and daily (bottom) NO_2 concentrations

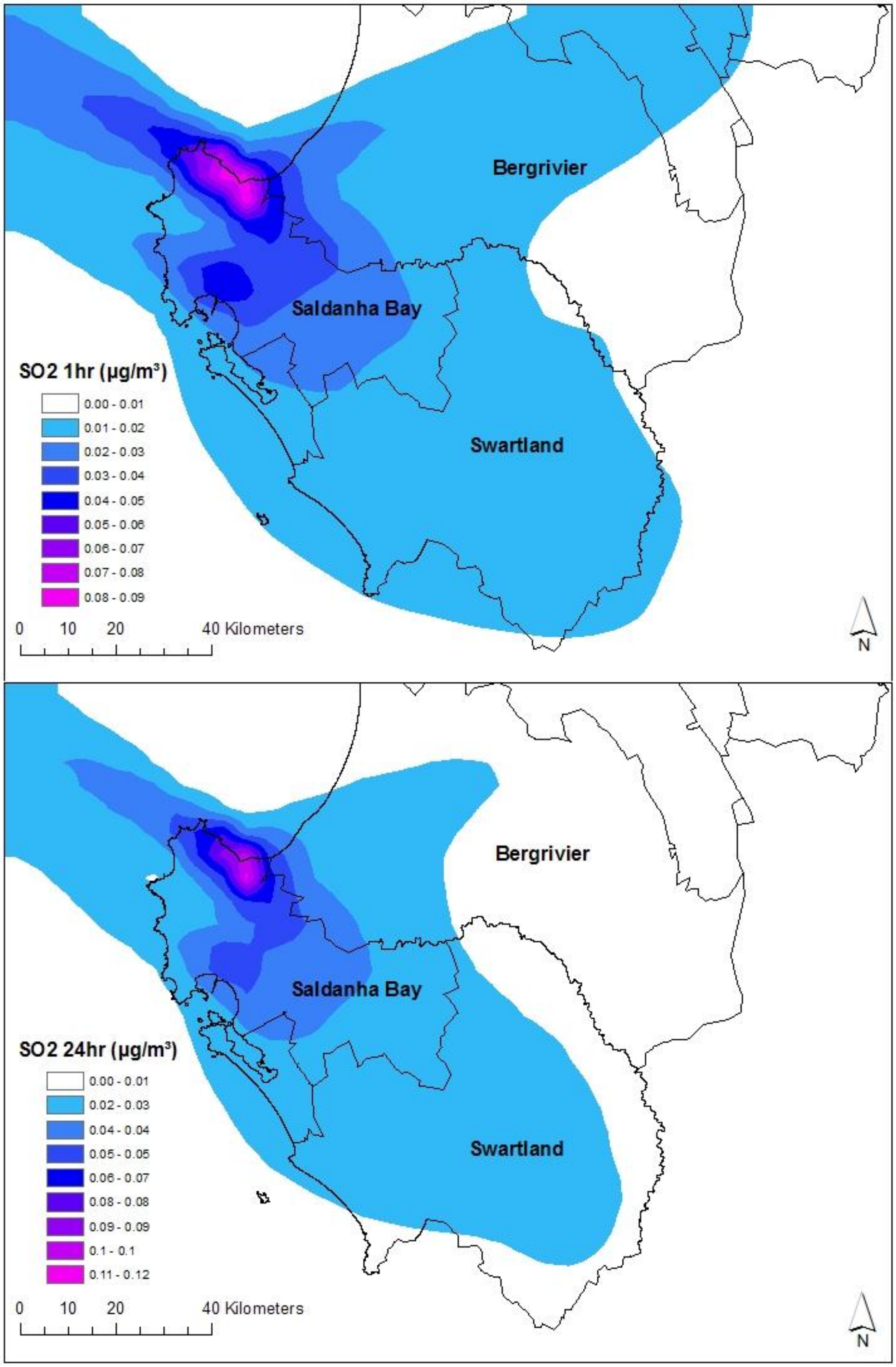


Figure 32: Average hourly (top) and daily (bottom) SO_2 concentrations

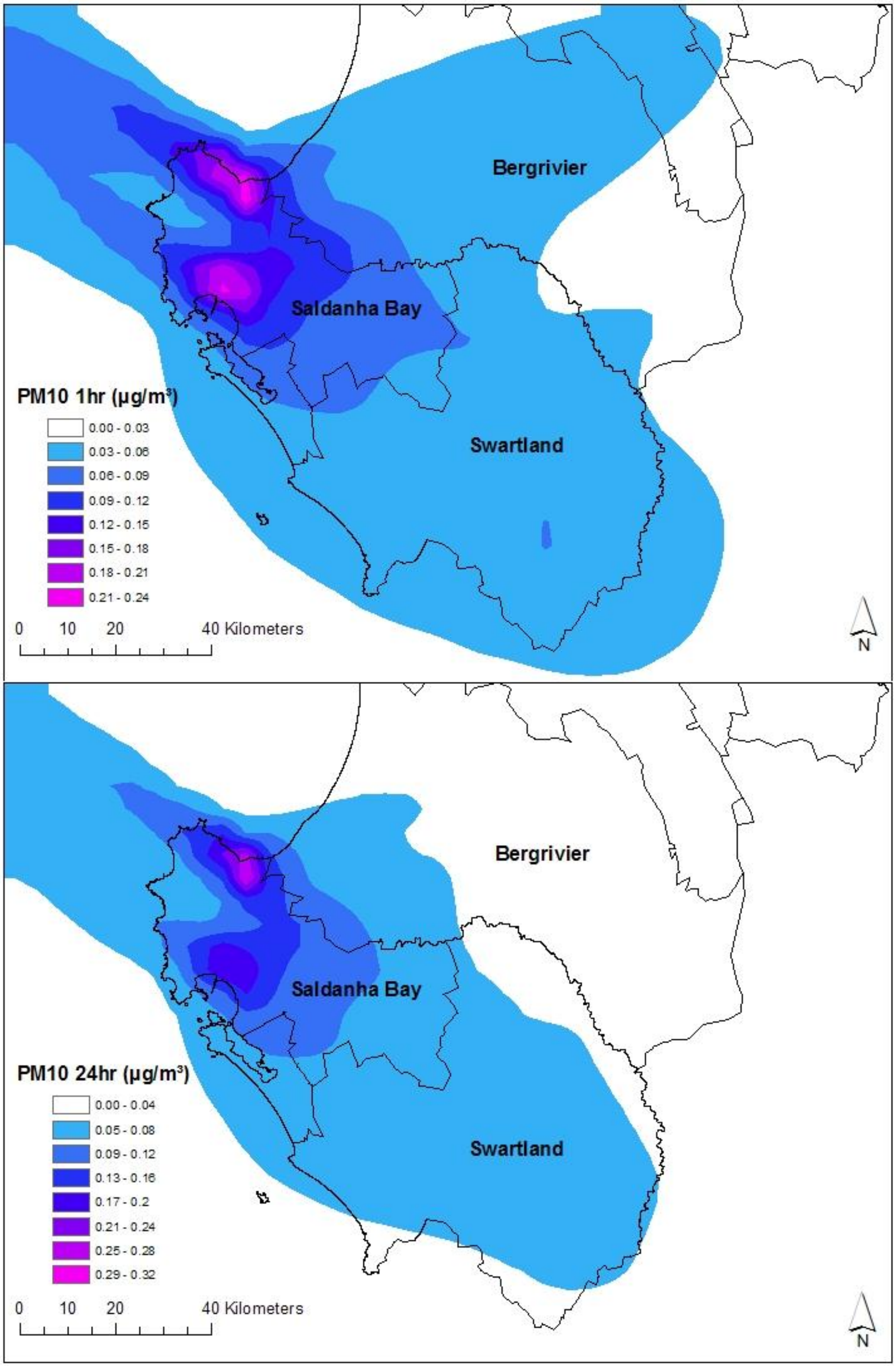


Figure 33: Average hourly (top) and daily (bottom) PM10 concentrations

6.3.4 Assumptions and Limitations

The following assumptions and limitations need to be taken into account for this assessment:

- Small Industries and boiler sources in the District were identified with assistance from the District Municipality and through questionnaires as part of the emissions inventory, however not quantified further.
- The emissions inventory of industrial sources in the District is incomplete and extremely limited. Where relevant stack and emissions parameters were not provided, use was made of default parameters. The Australian NPI emission factors were used in the calculation of emissions. The contribution of some main sources could not be evaluated as emission information for these sources was not provided.
- Domestic fuel burning emissions were estimated from the Census 2001 database of household fuel burning. Domestic fuel burning emissions are potentially overestimated for informal areas in the District as the recent Community Survey 2007 shows a decrease in the percentage of households using domestic fuels.
- Vehicle emission estimations were limited to fuel sales rather than traffic count data and are therefore likely to be overestimated. Assumptions were made regarding the petrol and diesel consumption rates of vehicles based on studies done by Vanderschuren and Jobanputra (2005), and Mårtensson (2003). Fuel sales within each local municipality are also not solely indicative of vehicle emissions within that region. Traffic count data could not be obtained.
- Only emissions from industries located in Saldanha Bay and Swartland Local municipalities were modelled. Industry is generally concentrated in these areas along with the majority of the region's population.

7. AIR QUALITY PRACTICES AND INITIATIVES WITHIN PROVINCIAL AND LOCAL GOVERNMENT

7.1. Government Structure and Functions

The capacity for air quality management and control within the West Coast District is assessed within the various spheres of Government. The current capacity at Provincial, District and Local levels is evaluated in terms of available personnel, functions and resources.

7.1.1. Provincial Level

Within the Western Cape Province, the Director of Pollution Management is responsible for air quality related functions. Within this Department, the Director of Pollution and the Provincial Air Quality Officer play a direct role in air quality management and control. Air quality is primarily a function of the Air Quality Management Deputy Directorate: Pollution Management. The organizational structure of the Air Quality Management Directorate is given in Figure 34.

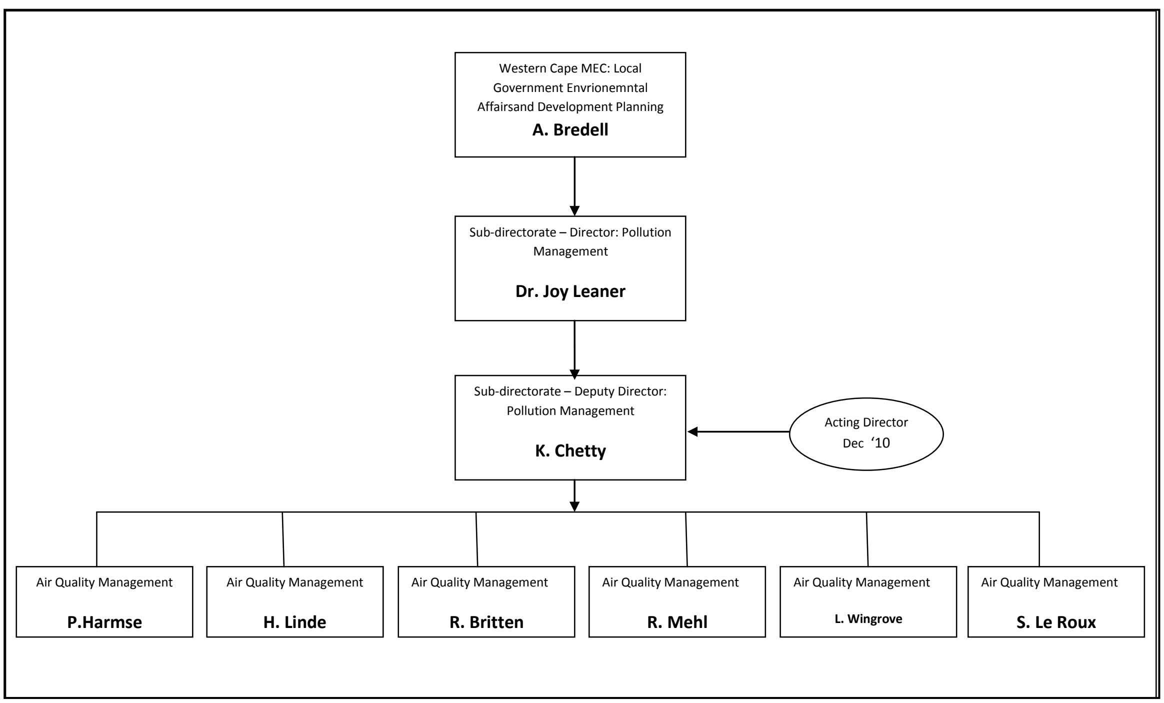


Figure 34: Organisational structure for the Air Quality Management of the Western Cape and Directorate: Pollution Management

Current air quality management initiatives and projects within the Department include the compilation of an emissions inventory database, source identification, an electronic reporting system, guidelines for the development of an air quality monitoring programme, pesticides aerosols drift management and receiving and reviewing quarterly reports from industries.

7.1.2. District Level

Within the West Coast District Municipality, Municipal Health Services (MHS) in the Department of Directorate Community Services is responsible for air quality management and control. Functions of Municipal Health Services also include some environmental services as described in the National Health Act 61 of 2003. These include water quality monitoring, food control, waste management, and health surveillance of premises, surveillance and prevention of communicable diseases, vector control, and environmental pollution control, disposal of the dead and chemical safety. The current structure for Local Government Air Quality Management in the West Coast District Municipality is shown in Figure 35.

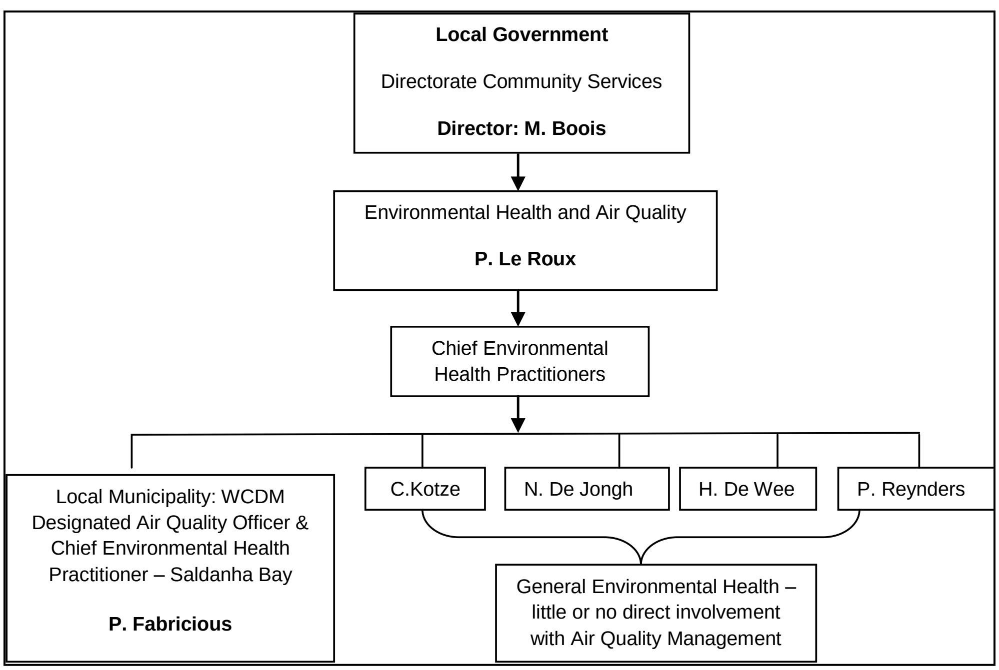


Figure 35: Organisational structure for the Local Government Air Quality Management of the West Coast District Municipality

The current capacity of the WCDM for Air Quality Management is:

- A Manager for Municipal Health Services, Responsible for the management of the Municipal Health Services section that include air quality
- A Chief Air Pollution Control Officer and 2 assisting officers: These positions are not fully functional as yet since the designated Air Quality Officer fulfills a dual function being that of Chief Environmental Health Practitioner in Saldanha Bay area as well as designated Air Quality Officer. The two “assisting officers” are trained Environmental Management Inspectors but have not been designated as yet. They are also functional Environmental Health Practitioners and report to Chief Environmental Health Practitioners and not the Air Quality Officer. Their involvement in air quality management at this stage is therefore limited.
- Four Chief Environmental Health Practitioners: The involvement of these practitioners is limited since they are also fulfilling a dual function being that of office heads in the five districts comprising of local municipal areas.

Note: The above-mentioned arrangement resulted from discussions between officials and should at this stage be regarded as proposals only. The structure still needs to be formalized, including the establishment of reporting lines, complete with job descriptions and specific responsibilities. It is also proposed that the three officials namely the Chief Air Quality Officer and two Air Quality Officers referred to as “assisting officers” be seconded to the air quality management section. The air quality section can then concentrate on air quality only. The four Chief Environmental Practitioners should actually be five that include the operational areas of Saldanha Bay, Swartland, Bergrivier, Cederberg and Matzikama.

Activities

- Air Quality Management and Control Functions: Ambient Air Quality Monitoring done by Province and certain industries and complaints register
- Reporting Practices: Receive monitoring data from province on a daily basis via e-mail – quarterly report submitted to Province via e-mail
- Current Air Quality Management Initiatives: Compiled list of fuel burning appliances
- Other information: Undertaking an APPA review process with the fishmeal industry

- Do inspections at listed activities;
- Attend to queries from industry with regards to Registration Certificates;
- Have quarterly meetings with industry and discuss quarterly reports and monitoring data;

7.1.3. Local Level

Current Capacity of Saldanha Bay Municipality for Air Quality Management:

- One Environmental Officer
- Two people working as Environmental Health Officers or Technicians
- NO Air Quality Management and control and NO reporting practices
- NO available Air Quality Software
- NO current Air Quality Management initiatives or emission reduction initiatives

Current Capacity of Swartland Municipality for Air Quality Management:

- One Air Quality Officer
- Air Quality Management and Control Functions: Monitoring and complaints
- Reporting Practices: Gathering information from province and daily reporting
- Air Quality Management Initiative: Monitoring Station
- No available Air Quality Software
- No implementation of Emissions reduction initiatives

Current Capacity of Bergrivier Municipality for Air Quality Management:

- One Air Quality officer (General Environmental Health)
- No Air Quality Management and control and NO reporting practices
- No available Air Quality Software
- No current Air Quality Management initiatives or emission reduction initiatives

Current Capacity of Matzikama Municipality for Air Quality Management:

- One Air Quality officer (General Environmental Health)
- No Air Quality Management and control and NO reporting practices
- No available Air Quality Software
- No current Air Quality Management initiatives or emission reduction initiatives

7.2. Air Quality Management Tools

7.2.1. Complaints Response Database

The West Coast District Municipality has a complaints register that is kept on a daily basis to log air quality complaints. Air pollution complaints that are received by the District are handled by the Environmental Health Practitioners (EHPs) in the Department of Community Services. This database is used to log air pollution complaints, and an environmental health practitioner is then dispatched to investigate the complaint. Once the complaint is deemed to be legitimate, the offender is requested to comply through an official letter, and provided with a timeframe in which they should comply. Bad odour from the fish industries is the main source of air pollution complaints within the West Coast District Municipality.

It is important that air pollution complaints received from the public are recorded in an electronic database, investigated and addressed within each level of Government. Pollution complaints need to be logged into a centralised electronic pollution complaints database at the Department of Environmental Affairs to ensure the effective co-ordination and management of complaints received. Prior to such a system being implemented, it is recommended that the District maintain a complete complaint system, keeping records of responses, letters, notices and feedback to the complainant.

7.2.2. Emissions Inventory Database

The development and regular maintenance of a comprehensive emissions inventory database is an important component of any air quality management system. The WCDM does have an emissions inventory database but it is incomplete due to the lack in participation of some industries. Such a database contains information regarding pollution sources (point, line, volume and area), source parameters (stack height, diameter, gas exit velocity, gas exit temperature) and emission rates.

7.2.3. Dispersion Modelling Software

Limited software and knowledge exists within each sphere of Government to support dispersion modelling. Dispersion modelling software is not available at either the Local or District levels. The use of such modelling software is critical to the understanding of the temporal and spatial distribution of pollutants in the atmosphere.

7.2.4. Data Reporting Practices

Ambient air quality monitoring is currently undertaken by Province. The data from the network is downloaded directly from the stations by a service provider appointed by Province and then copied to the air quality personnel at the District Municipality. Air Quality Monitoring networks are also maintained by some of the big industries and this Data are made available to Province and WCDM on request.

Within South Africa, the coordinated transfer of data from all monitoring stations to a centralised database is a critical component to ensure the effective and efficient management and verification of the monitoring data. As part of the South African Air Quality Information System (SAAQIS), a centralised database will be developed at the South African Weather Services to which all verified ambient monitoring data will be transferred and data based.

8. CAPACITY BUILDING WITHIN LOCAL GOVERNMENT

8.1. Human Resources

As per Schedule 4, Part B, Section 156 of the Constitution, air pollution is an exclusive function of the Local Municipalities. Air quality functions are therefore, primarily the responsibility of the Local Government, with support to be provided from Provincial and National Government. Within the West Coast Municipalities District, support is provided to the Local Municipalities by the District Municipality and Western Cape Province.

Air quality functions are primarily the responsibility of the District Municipality, with little to no capacity for air quality management in the Local Municipalities. For the West Coast District AQMP to be effective, co-operative governance and political buy-in across all spheres of government will be required, as well as the capacity to enforce compliance with the new legislation. In terms of the Air Quality Act, air quality management and control is primarily a function of the Local Municipalities with emission licensing functions undertaken District Municipalities. In order to increase the capacity in Municipalities, authorities need to invest both time and capital. For Municipalities to fulfill their regulatory role in terms of air quality, dedicated Air Quality Officers and personnel need to be appointed.

Universities and Technikons do not have dedicated courses and degrees in Air Quality Management and Modelling. Courses in Atmospheric Chemistry and Environmental Management specific to air are only part of other courses. Environmental Health Practitioners are trained specifically on occupational health and safety issues related to environmental health with some focus on ambient air quality issues. Certain universities such as the University of Johannesburg and the University of Potchefstroom do offer short courses in air quality management. Such courses focus on air pollution topics such as sources of air pollution, meteorology, emissions inventory compilation, dispersion modeling, air quality monitoring and air quality management planning. All existing and newly appointed Air Quality Officers should be sent to undergo such training.

Municipalities are also required to undertake monitoring, data analysis and reporting on ambient air quality as per their mandate as air quality authorities. Training on calibration and maintenance of analysers in ambient monitoring stations will be required, as well as training on data acquisition and the analysis thereof. For this task, technical personnel will need to be appointed. Some of these functions are currently undertaken to some extend within the West Coast District but resources and personnel are urgently needed.

According to legislation, Municipalities are required to appoint an Air Quality Officer. Currently, no dedicated Air Quality Officers have been appointed at either the District or the Local Municipalities, with air quality functions forming part of other responsibilities. In the WCDM there is currently one Air Quality officer who is also appointed as Chief Environmental Officer of the Saldanha Bay Local Municipality. This means that duties relating to Air Quality Management within the WCDM cannot be given individual attention. At a minimum, the following appointments are recommended within the District Municipality:

• One Air Quality Officer (with no other duties except Air Quality related duties)

After discussing the current status of the capacity of the WCDM to effectively manage air quality in the district we recommend that at least two air quality officers, (could be EHP allocations) as interim arrangement, be appointed at WCDM to cover the whole of the area that include local municipalities). Further support can be obtained through designation of the Environmental Officer of WCDM. As suggested earlier in the report,

post incumbents can be recruited internally since the two “assistants” referred to are already trained as EMI’s. t is therefore suggested that a Chief Air Quality Officer and at least one Air quality Officer be appointed or designated. Also refer to Figure 36, “preferred option”: Chief Air Quality Officer plus two Air Quality Officers.

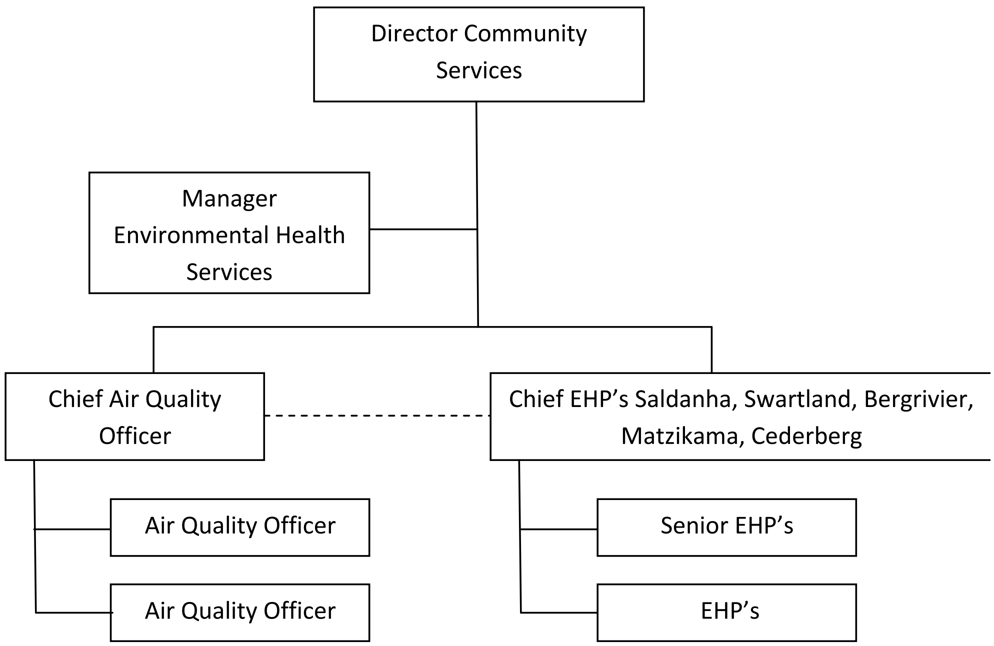


Figure 36: **Preferred organizational structure for air quality management in WCDM area of jurisdiction**

This person(s) will be responsible for air quality management within both the District and Local Levels (until such capacity is available within each Local Municipality). This person should have a good understanding of air quality issues within the West Coast District. Duties and functions of Air Quality Officers, as outlined in AQA, include:

- Coordinating the development , implementation and revision of an Air Quality Management Plan,
- Preparing the Municipal Air Quality Officer's Annual Report. The report should include the Municipality's progress towards the implementation of its Air Quality Management Plan,
- Submitting the Municipality's report to the Provincial Air Quality Officer,
- May require the holder of an atmospheric emission license to appoint an Emission Control Officer.
- Emission licensing of scheduled processes,

Other responsibilities could include:

- General air quality management and control,
- Development and maintenance of a comprehensive emissions inventory for the District (including point, non-point and mobile sources),
- Undertake dispersion modeling simulations of predicted pollutant concentrations,
- Enforcement and control of non-scheduled processes,
- Training of Environmental Management Inspectors (EMIs)

• One Air Quality Technician (This expertise can be appointed on a contract basis as and when required)

This person will be responsible for the technical aspects of air quality management including maintenance and calibrations of ambient air quality monitoring stations as well as the co-ordination and implementation of passive sampling campaigns. This person will report directly to the Air Quality Officer. Within the Local Municipalities, it is recommended that an Air Quality Officer be appointed in the Saldanha and Swartland Local Municipalities given the occurrence of most major industries in this Local Municipalities. Until such a time that this appointment is made, WCDM should continue

to undertake all air quality functions in Saldanha and Swartland as well as Bergrivier, Cederberg and Matzikama through a service level agreement.

It is recommended that this is done through a Memorandum of Understanding (MOU) (Appendix B) should Local Municipalities be willing to designate an official who must be held responsible for day to day air quality issues within a specific local municipal area. The draft MOU should be negotiated with the Local Municipalities and should, once approved and signed, be used as a tool to coordinate the function. Should local Municipalities however indicate that they don’t have the capacity to deliver the function the other option of SLA’s must be considered. The West Coast Air Quality Working Group chaired by the WCDM can be another vehicle to manage this interaction between District and Local Municipalities. It is also important to note that all Local Municipalities are legally required to designate an Air Quality Officer and to draft an Air Quality Management Plan.

The importance of the air quality function must be conveyed to senior management at Local as well as District Municipal level and they should be made aware of the financial implications (that should be budgeted for). These issues should also receive priority attention during the public participation process. Provision must be made for training of EHP’s and other staff as EMI’s. I n order for the WCDM to render an Air Quality service of an acceptable standard it is important that the preferred option in Figure 36 be seriously considered.

8.2. Air Quality Management Tools

8.2.1. Emissions Inventory Database

Province has an existing Emissions Inventory Database for point and area source and has future plans to expand Emission Inventory database to mobile sources. The WCDM has compiled a list of burning appliances and listed activities within the District but this list needs updating and completion. For effective air quality management and control, an accurate, electronic emissions inventory of point, non-point and mobile sources needs to be established, regularly updated and maintained. An emissions inventory includes information on source parameters (source location, stack height, stack diameter, exit gas velocity, exit temperature) and associated pollutant emission rates. An emissions inventory serves the following functions -

- Providing spatially resolved source strength data on each pollutant for dispersion modeling,
- Predicting environmental impacts,
- Helping in urban and regional planning,
- Supporting the design of regional monitoring networks,
- Contributing a basis for evaluating trends,
- Assisting in the formulation of air quality management policies.

Emissions inventories can either be developed by a) estimating emissions using emission factors and manually integrating into a database or by b) using existing emissions inventory software which has built-in emission factors. The selection of software for this purpose should take into account the applicability of this software for the local environment, accessibility to software support and its interface between a suitable dispersion model and Geographical Information System (GIS). Possible emissions inventory software for this purpose includes the Cambridge Environmental Research Consultants (CERC) EMIT software, which is already being used by the City of Johannesburg Metropolitan Municipality, Ekurhuleni Metropolitan Municipality and the City of Cape Town Metropolitan Municipality.

As the WCDM is not considered to be an industrialised area, with a limited number of industrial sources, it is not necessary for the District to purchase emissions inventory software. Use can be made of available software such as Microsoft Excel or Microsoft Access to capture the emissions inventory information supplied by industries.

As part of the South African Air Quality Information System, all source and emissions data recorded within each Municipality and Province will be incorporated into a National electronic database, allowing for easy access and manipulation of data from any sphere of Government. The WCDM will need to ensure that their current emissions inventory database is regularly updated and that it is incorporated into the SAAQIS.

8.2.2. Dispersion Modelling Software

Atmospheric dispersion modelling forms an integral component of air quality management and planning. Air quality models are used to establish a relationship between emissions and air quality. Dispersion models require the input of data which includes:

- Meteorological conditions such as wind speed and direction, the amount of atmospheric turbulence, ambient air temperature and the height to the bottom of any inversion layers in the upper atmosphere,
- Emission parameters such as source location and height, stack diameter, exit gas temperature and exit velocity,
- Terrain elevations at the source and surrounding regions,
- Location, height and width of any obstructions (such as buildings).

Dispersion modelling is typically used to determine compliance with ambient air quality guidelines or standards, assist in health and environmental risk assessments, provide information for ambient monitoring networks and to assess source contributions to air quality concentrations.

When selecting an appropriate model, the following considerations should be taken into account, including:

- Applicability to the local environment, in particular, an urban airshed,
- Compatibility with a GIS such as ArcGIS 9.2,
- Compatibility with emissions inventory software,
- Availability of meteorological data (ie should upper air data be required),
- Accessibility to software support (local and international),
- Chemical reactions such as ozone formation,
- IT requirements.

Within South Africa, a range of urban airshed models are currently being utilised, including ADMS Urban by the City of Johannesburg, Ekurhuleni Metropolitan Municipality and the City of Cape Town, the Norwegian AirQuis model by eThekwini Metropolitan Municipality and the locally developed Dynamic Air Pollution Prediction System (DAPPS) model, the latter not currently available for purchase. Other USEPA regulatory models such as CALPUFF and AERMOD are freely downloadable from the USEPA website. CALPUFF is designed to model long-range transport of pollutants and is most applicable in areas of complex terrain. AERMOD, which has replaced CALPUFF as the USEPA approved regulatory model, is considered to be labour and data intensive for local applications.

DEA are in the process of developing an internal discussion document which relates to dispersion modeling in general. Once this document has been developed, DEA will be in a position to provide guidance to Municipalities on dispersion modelling. This document will take into account a wide range of factors including the cost of the models, the cost of support and training and model validation and appropriateness for use in South Africa (Scott, G, *pers. comm*).

8.2.2.1. ADMS

The Atmospheric Dispersion Modelling System consists of the suite of models ADMS-Screen, ADMS 3 and ADMS-Urban. ADMS-Screen is used to assess the potential impact of a single point source, ADMS 3 is used to assess the impact of industrial sources and ADMS-Urban is used to model emissions from a number of sources within an urban area. ADMS-Roads is a new model that has recently been developed to specifically address the impact of roads to pollutant concentrations. Of these, ADMS-Urban will be discussed in detail as it is the model most applicable to urban environments.

ADMS Urban was developed by Cambridge Environmental Research Consultants (CERC) in collaboration with the University of Surrey and the UK Meteorology Office. ADMS-Urban is a dispersion and transport model based on ADMS 3, specifically for air quality calculations across urban areas. It models point, line, area and volume sources and it is able to consider multiple grid sources including industrial, domestic and road traffic emissions in a large urban area. For example road sources relatively close to the

area being modelled are characterised explicitly by a number of parameters whilst more distant road sources are aggregated onto a grid.

The model can be applied to flat and complex terrain (which is limited and based on surface roughness) and also considers buildings and street canyon effects. It is able to calculate pollutant concentrations for 15 minutes (short term) to 1 year (long term) averaging times. Percentiles can also be calculated for comparison with regulatory standards. Chemical reactions involving NO_x, O_3 and VOC's can also be modelled using trajectory model algorithms (CERC, 2000).

ADMS-Urban has been used in various studies in the UK, Europe and around the world (CERC, 2003) including London, Ireland, Wales, China, Budapest, India, South Africa and the US. Validation studies have been carried out by Carruthers *et al* (1999, 2000, 2003) in London which showed good agreement between the modelled and observed results. Carruthers et al (2000) compared measurements from an urban area (within a 1 km grid and roads with more than 25 000 vehicles a day) and industrial locations in London, Ireland and Wales. There was good correlation between modelled and monitored NO_x concentrations but the model did under predict concentrations at night and during winter (Holmes and Morawska, 2006). However, SO_2 concentrations correlated poorly and were found to be very sensitive to wind direction. Hanna et al (2001) undertook an evaluation of the ADMS, AEROMOD and ISC3 models. ADMS-Urban was found to under predict on average by 20%, with a scatter of about a factor of 2. ADMS has 53% of its predictions within a factor of 2 of observations.

8.2.2.2. CALPUFF

CALPUFF is an advanced, integrated, non-steady-state Gaussian puff modelling system consisting of three main components and a set of pre-processing and post processing programs. The main components are CALMET (a diagnostic three-dimensional meteorological model), CALPUFF (a puff dispersion model) and CALPOST (a postprocessor package). It models the dispersion of gases and particles using time and space varying meteorological conditions based on turbulence, emission strengths, pollution transport, transformation and removal.

The model is designed to simulate the dispersion from point, area, volume and line sources integrating the effects of plume rise, partial penetration, buoyant and continuous plume rise and stack effects. It can be applied for long range transport (tens to hundreds of kilometres) and complex terrain. It includes algorithms for sub-grid scale, longer range effects (such as wet and dry deposition, chemical transformation and visibility effects) and downwash effects by buildings.

The USEPA has recommended CALPUFF for long range transport modelling (greater than 50 km from the emission source) due to its ability to process complex three-dimensional wind fields (USEPA, 2002). Chemical transformations are modelled using a pseudo-first-order chemical reaction mechanism, in MESOPUFF, for the conversion of SO_2 to SO_4^- and NO_x to NO_3^-. However, the model is not recommended for use in estimating the impact of NO_x and SO_2 on secondary particulate formation less than 10 km from a source. The model can also utilise user defined diurnal cycles of transformation rates (Elbir, 2003).

CALPUFF has been used in a number of studies to investigate gas dispersion in the US and around the world including Illinois, South Carolina, Oklahoma, Christchurch (New Zealand), Beijing (China), Izmir (Turkey), Mexico and South Africa. During a study by Villasenor et al (2003) in south-east Mexico the model under predicted SO_2 concentrations in a complex environment among several gas and oil exploration and production sites. In validation studies, however, the model showed reasonable agreement with pollutant concentrations and inconsistency was mainly due to unknown sources. However, CALPUFF is not recommended for calculation of timescales shorter than 1 hour or where dispersion is heavily influenced by turbulence such as in an urban environment (Holmes and Morawska, 2006).

8.2.3. Ambient Air Quality Monitoring

An ambient air quality monitoring system consists of various hardware, software, communication systems as well as activities related to the ongoing maintenance and calibration of the system. Continuous ambient air quality monitoring requires among other things; a set of trace gas analysers housed in a secure shelter, meteorological equipment, a data communication and acquisition system, as well as various other mechanical, civil and electrical structures such as an inlet manifold, fencing, concrete plinth, air conditioner, Uninterrupted Power Supply (UPS) and safety devices such as a

lightning conductor. As part of a monitoring network design (macro and micro-siting) it is important to consider the following aspects:

- Proximity to residential areas,
- Location of industries, major roads, sources of domestic fuel burning emissions etc,
- Dominant wind direction,
- Dispersion modelling results,
- Topography,
- Location of existing monitoring stations,
- Sensitive environments,
- Sensitive populations,
- Trans-boundary transport of air pollution from neighbouring sources.

8.2.3.1. Continuous Ambient Air Quality Monitoring

Continuous ambient air quality monitoring of atmospheric emissions ensures that the environment is being properly protected and helps Local Government manage their impact on the environment. (Figure 37) This type of monitoring provides continuous, accurate data on pollution concentrations at a specific location. However, limitations of this type of monitoring are associated with spatial coverage, technical skills required for maintenance and calibration as well as the ongoing financial implications.

Figure 37: Continuous ambient air quality monitoring equipment.

Figure 38: **Pole mounted monitoring station: AeroQuals**

Municipalities would need to acquire air monitoring equipment as well as a system that will automatically retrieve air quality data from loggers and sensors for the management of remote data acquisition equipment. This system should have data correction functions for quality assurance. An ambient air quality monitoring station requires a person responsible for maintaining the network, calibrating the instruments as well as analysing data and compiling reports for compliance assessment. A pole mounted monitoring station would be acceptable for the Local Municipalities and a complete reference Air Quality Monitoring Station should be established in the Saldanha Bay Area which is the most populated and industrialized area.

An ambient air quality monitoring station requires ongoing maintenance and calibration and is not just a once-off capital expense. Ongoing maintenance costs should be budgeted for at the onset of the project. Approximate costs associated with the installation, operation and maintenance of a complete ambient air quality monitoring station are given in Table 21. Options for continuous monitoring include a permanent (stationary) monitoring station (stationed in the Saldanha Bay area) or a caravan (mobile) monitoring station. A mobile monitoring station provides flexibility to undertake measurements at many locations for short periods of time to investigate local pollution

and determine whether a permanent station is required. Mobile monitoring is considered to be a more cost-effective option for the District when considering the location and extent of air pollution sources in the District. For a permanent station in the Saldanha Bay area the District could work with Industry which already has some air monitoring stations.

At a minimum, it is recommended that any ambient monitoring station installed in the Saldanha Bay Area and it should measure a range of pollutant and meteorological parameters as described in Section 7.3.3.3. The stations should be undertaken on a regular basis, with zero and spans performed every two weeks and a full dynamic calibration undertaken every three months. In addition, all stations should obtain SANAS accreditation to ensure the standardisation of monitoring practices in the region.

8.2.3.2. Passive Diffusive Monitoring

Passive monitoring is an inexpensive method of monitoring over a large area and requires little human intervention (Figure 39). Passive badges can measure a range of pollutants including SO_2, NO_2, O_3, hydrogen sulphide (H_2S), hydrochloric acid, VOCs, and various aldehydes among others. Passive diffusive sampling calculates an average reading over a time period as opposed to real-time data acquisition that continuous monitoring can provide. Passive badges have to be sent away to an accredited laboratory for analysis further extending the lag time in getting results (2 – 3 weeks). Passive sampling conforms to international methodologies and standards and can be used to validate dispersion modelling results.

However, there are limitations associated with passive monitoring. These include questionable concentrations given that passive badge monitoring is based on diffusion of pollutants while comparison with ambient air quality guidelines/standards is difficult. Extreme meteorological conditions such as high humidities and temperatures influence diffusion rates, and hence, affect concentrations. Passive monitoring should be acceptable for the other Local Municipalities, apart from Saldanha Bay, to be established in their biggest towns.

Figure 39: Passive badge sampling equipment.

8.3. Financial Implications

The required budget for the District is evaluated in terms of the required human resources, software and hardware for air quality monitoring and management within the District. Please note that these are approximate figures.

Table 19: Approximate costs for the appointment of air quality personnel in the WCDM.

Position	Unit	Required	Approximate Price
Air Quality Officer	Per annum	1	R 450 000
Senior Environmental Officer	Per annum	2	R 300 000
Senior Administrator	Per annum	1	R 156 000
TOTAL			**R 1 206 000**

Table 20: Approximate costs for emissions inventory and dispersion modeling software and hardware.

Requirements	Unit	Approximate Price
Software and Hardware		
ADMS Urban (Permanent Licence)	Once off	R 140 000
Annual technical support for ADMS Urban *(optional)*	Per annum	R 30 000
EMIT (Permanent Licence)	Once off	R 35 000
ArcGIS 9.2 and Spatial Analyst	Once off	R 40 000
Computer	Once off	R 6 000
Other		
ADMS Urban and EMIT Training	Per Person	R 7 000
TOTAL		**R 258 000**

Table 21: Approximate costs for the installation, operation and maintenance of a complete ambient air quality monitoring station for a period of one year.

Requirements	Unit	Approximate Price
Equipment		
Trace Gas Analysers (SO_2, NO_x, O_3 and CO)	Four analysers	R 500 000
PM10 Instrument (Beta Gauge)	Per instrument	R 140 000
PM2.5 Instrument	Per instrument	R 150 000
Gas Chromatograph (VOCs)	Per instrument	R 300 000
Meteorological station (1)	Per station	R 60 000
Shelter, air conditioner, glass inlet manifold, UPS and alarm system	Once off	R 150 000
Installation		
Civils (concrete plinth and fencing)	Once off	R 50 000
Delivery, Installation and Commissioning	Once off	R 30 000
Operation and Maintenance		
Zero and spans every two weeks (outsourced)	Every two weeks	R 60 000
Full Dynamic Calibration (outsourced)	Quarterly (4)	R 20 000
Meteorological Calibration	Per annum	R 16 000
Consumables, maintenance and repairs for Point Source analysers	Per annum	R 30 000
SANAS Accreditation *(optional)*		
SANAS accreditation calibration (by a SANAS accredited laboratory)	Four Analysers	R 12 000
Preparation of quality manual and application to SANAS	Once off	R 90 000
SANAS accreditation audit (by SANAS)	Per annum	R 13 000
Hardware and Software		
Data acquisition and communication for Point Source analysers	Once off	R 100 000
Data transmission and verification for Point Source analysers	Per annum	R 30 000
TOTAL (Point Source)		**R 1 751 000**

Note: (1) Wind speed, wind direction, temperature, humidity, solar radiation, pressure, rainfall and 9 m mast

Equipment and associated costs are provided for Thermo point source analysers. Other equipment options include Teledyne-Advanced Pollution Instrumentation, Open Path Monitoring System (OPSIS) etc. A second open monitoring system would be required to measure CO, therefore it is recommended that should an open path monitoring system be purchased, a CO point source analyser be used to reduce the costs.

Table 22: Approximate costs for the installation, operation and maintenance of a pole mounted street ambient air quality monitoring station for a period of one year.

Requirements	Unit	Approximate Price
Equipment		
ADD Pole mounted Analysers	3 analysers	R 1,200,000
Operation and Maintenance		
Calibrations, data management ect.	3 analysers	R 450,000
TOTAL (Point Source)		**R 1,650,000**
Equipment and associated costs are provided for Aeroqual analysers which are recommended for the WCDM's purposes.		

Table 23: Total cost for the implementation of an air quality system in the West Coast District.

Requirements	Approximate Price
Human Resources	R 1 206 000
Software and Hardware	R 258 000
Ambient Air Quality Monitoring	R 1 751 000
Provision of spares and repairs (per annum)	R300 000
TOTAL	**R 3515 000**

9. IMPLEMENTATION OF AIR QUALITY MANAGEMENT PLAN

Considering the current capacity of the West Coast District Municipality regarding, human resources, air quality management tools and ambient air quality monitoring, different strategies have to be used to implement the AQMP. Strategies are also proposed to reduce emissions in the area or to control the emissions to ensure that the air quality within the District remains the same.

9.1. Human Resources

Table 24 Implementation of human resources needed in the WCDM

Human Resources					
Intervention	Implementation Strategy	Responsible	Assumptions	Time Frame	Indicators
Appoint a Chief Air Quality Officer in WCDM	District Municipality to appoint one dedicated and skilled Chief Air Quality officer (Air Quality Officers to attend Air Quality courses)	WCDM	Funding is available for personnel appointments	Short Term	A Chief Air Quality Officer is appointed in the QCDM - Air Quality is effectively Managed and Controlled
Appoint an Air Quality Officer in WCDM	District Municipality to appoint at least one (2 preferable) dedicated and skilled Air Quality officer (Air Quality Officers to attend Air Quality courses)	WCDM	Funding is available for personnel appointments	Short Term	An Air Quality Officer is appointed in the QCDM - Air Quality is effectively Managed and Controlled
Appoint an Air Quality Technician in WCDM	District Municipality to appoint at least one dedicated and skilled Air Quality Technician (Can be appointed on contract basis or when required)	WCDM	Funding is available for personnel appointments	Short Term + Medium Term	An Air Quality Technician is appointed - all technical aspects of Air Quality Management are attended to

9.2. Air Quality Management Tools

Table 25 Implementation of Air Quality Management Tools needed in the WCDM

Air Quality Monitoring Tools					
Intervention	Implementation Strategy	Responsible	Assumptions	Time Frame	Indicators
Emissions Inventory	Update and maintain existing Emissions Inventory	WCDM	WCDM has an electronic Emissions Inventory	Short to Long term	Emissions inventories are collated into a centralised, electronic emissions data base held by SAWS
Dispersion Modelling	Dispersion Modelling should be done periodically (every 5 years). If there is evidence that the air quality is degrading, dispersion modelling should be done annually.	WCDM or subcontractor	WCDM has the expertise to do dispersion modelling or has funding available to have dispersion modelling done	Medium to Long term	Modelling of emissions to determine distribution and hotspots

9.3. Ambient Air Quality Monitoring

Table 26 Implementation of Air Quality Monitoring needed in the WCDM

Ambient Air Monitoring					
Intervention	Implementation Strategy	Responsible	Assumptions	Time Frame	Indicators
Ambient Air Quality Monitoring Network	It is proposed that a full Air Quality Monitoring Station be established in the Saldanha Bay Area. This could also be achieved by working together with industry where there are existing air monitoring stations	WCDM and Industry	Finances available for Air Quality Monitoring Network	Medium to Long Term	Ambient monitoring of atmospheric emissions ensures that the environment is protected and helps local government to manage their impact on the environment
	Indicator Air Monitoring Stations (e.g. pole mounted stations) should be established in each of the other Local Municipalities in their biggest towns.	WCDM, Local Municipalities or subcontractor	Finances available for Air Quality Monitoring Network	Medium to Long Term	Ambient monitoring of atmospheric emissions ensures that the environment is protected and helps local government to manage their impact on the environment

9.4. Emission Reduction/Control Strategies

Table 27 Emissions reduction/control strategies to be implemented in the WCDM

Emissions Reduction/Control Strategies					
Intervention	Description	Implementation Strategy	Responsible	Time Frame	Indicators
Reduce/Control Domestic Fuel Burning	Some households still use fuels such as wood and paraffin for household purposes. This can be a contributor to some air pollution in the area but should not be of major concern. Emissions from domestic fuel burning should however be accurately determined to ensure that the contribution to the overall ambient air quality in the District is accurately quantified.	• Review domestic fuel burning emissions inventory with updated population statistics as these become available • Create awareness campaigns around the negative health impacts and dangers of domestic fuel burning • Implement Basa Njenjo Magogo method in informal settlements • Encourage the distribution of alternative forms of domestic energy • Integrate energy efficiency measures in low-cost houses such as housing insulation, solar panels and stove maintenance and replacement • Electrification in informal settlements	Local Municipalities or WCDM or Province	Short to Long Term	Air Quality within the WCDM is controlled. Impact of domestic fuel burning activities on the air quality in WCDM is monitored controlled.
Control of Transportation emissions	Transportation in the WCDM could be a contributor to air pollution in the District. Transportation consists of vehicle, aeroplane, train and shipping transportation. The impact on air quality by transportation activities should be controlled in the WCDM	• Review vehicle emissions database with updated traffic count data as these become available • Establish a comprehensive vehicle emissions monitoring and diesel vehicle testing programme in congested areas • Compile a detailed assessment of the vehicle fleet in the District including information on vehicle numbers, type, age and fuel usage • Regulation of diesel driven vehicles • Enforce emission standards developed as part of the National Vehicle Emission Standards	Local Municipalities or WCDM or Province or National	Short to Long Term	Air Quality within the WCDM is controlled. Impact of transportation activities on the air quality in WCDM is monitored and controlled.
Control of Emissions from mining activities	Mining is not a very prominent activity in the WCDM and should not be a major concern. It should however be monitored to ensure that the good air quality air quality in the district is maintained	• Develop comprehensive emissions inventories for each mine and update existing inventories • Obtain emission reduction/control strategies from mines • Regular maintenance and annual roadworthy checks of all mine vehicles • Ambient air quality monitoring (dust fallout, continuous, passive)	Local Municipalities or WCDM	Short to Long Term	Air Quality within the WCDM is controlled. Low impact of mining activities on the air quality in WCDM is maintained.
Control of Emissions from agricultural activities	Agriculture is a dominant land-use within many areas of the WCDM. Various activities within the agricultural sector could have an impact on air quality within the district. Emissions are however difficult to control due to seasonality and large surface area. It is however assumed, looking at the current air quality of the District that agricultural activities do not pose a major threat to air quality.	• Obtain information on the quantity of pesticides consumed in the West Coast District • Ensure that crop spraying takes place under favourable atmospheric conditions that reduce spray drift, i.e. when wind speeds and temperatures are low • Agricultural burning should only be allowed under favourable dispersion conditions which occur in the middle of the day.	Local Municipalities or WCDM	Short to Long Term	Air Quality within the WCDM is controlled. Impact of agricultural activities on the air quality in WCDM is controlled.
Control of Emissions from industrial activities	Industrial activities in the WCDM is controlled and not a major threat to air quality at the moment. It should however be monitored to ensure that the good air quality air quality in the district is maintained	• Update and maintain inventory of industries in the District • Update the current database of all small industries in the District • Periodic site inspections and emissions measurements • Develop a permit system for all non-listed activities	Local Municipalities or WCDM	Short to Long Term	Air Quality within the WCDM is controlled. Low impact of industrial activities on the air quality in WCDM is
Control of Emissions from waste treatment disposal activities	Waste treatment and disposal methods which are of interest in terms of the toxicity and odiferous nature of their emissions. Emissions from waste treatment activities may have an effect on air quality but is difficult to determine due to limited data. Emissions from landfills are a concern in terms of the potential for health effects and the odours generated. Pollutants released by waste water treatment and incinerators also has an impact on air quality within the District.	• Maintain or establish a database of permitted and non-permitted landfill sites • Ensure waste disposal sites are in compliance with DWAF minimum requirements • Introduce awareness programmes and public education of waste minimization and recycling initiatives • Reduce illegal dumping and the creation of informal landfills through efficient service delivery in residential areas • Undertake landfill gas monitoring and management schemes • Promote landfill rehabilitation schemes	Local Municipalities or WCDM	Short to Long Term	Air Quality within the WCDM is controlled. Impact of waste treatment activities on the air quality in WCDM is determined and controlled.
Control of Emissions from biomass burning	Emissions arising from biomass burning are difficult to accurately quantify due to the seasonal and irregular nature of this source. However, biomass burning is recognised to be an important contributor to the ambient air quality in the District, especially in terms of particulate emissions. Unauthorised burning does take place in the District as communities are not accustomed to or aware they are required to hold a permit to burn.	• Identify and quantify emissions from biomass burning • Identify the role of fire services to assist in air pollution control • Each local Fire Department to maintain and update a database of the locations of veld fires and the extent of the areas burnt • Regional scheduled burn areas that are published for agricultural and management fires • Inform the public about biomass burning licenses and encourage apllications	Local Municipalities or WCDM	Short to Long Term	Air Quality within the WCDM is controlled. Impact of biomass burning on the air quality in WCDM is determined and controlled.

9.5. By-law Promulgation

The Air Quality By-law created for the WCDM must be implemented and promulgated as soon as it is approved by the relevant authorities.

10. CONCLUSION AND THE WAY FORWARD

10.1 Conclusion

In section one a geographic overview of the West Coast and the different District Municipalities was given. The methodology of developing an AQMP was outlined and discussed. In section two the relevant and important legislation regarding Air Quality Management within Provincial, District and Local level was discussed. In section three the different pollutants were identified and their associated impacts regarding health and the environment and a meteorological overview of the West Coast District was done in section four to determine the effect that meteorology could have on air quality in the district.

In the status quo section of this report the baseline emissions inventory was discussed and the gaps regarding the emissions inventory. Pollutants, sources of the pollutants and impact areas were looked at and it was found that the air quality over the WCDM area of jurisdiction was in a good state, with the higher pollutant concentrations in the more industrialised areas like Saldanha Bay and Swartland.

In section six the current air quality practices and initiatives within local government were discussed. A capacity analysis was done in order to identify the gaps and restraints within the WCDM to effectively management air quality in the district. Recommendations were made that must be implemented to ensure effective Air Quality Management in the WCDM. Concrete suggestions and strategies are given in section eight to successfully implement this AQMP.

It was found that the West Coast has no significant problem regarding the quality of their air. The implementation of this AQMP is therefore recommended to control emissions in the area and maintain the current quality of the air in the District.

10.2. Way Forward

The Air Quality Management Plan for the West Coast District Municipality must be approved by Council and then be implemented within the WCDM according to the National Environmental Management: Air Quality Act 39 of 2004 (AQA) which requires Municipalities to introduce Air Quality Management Plans (AQMP) that set out what will be done to achieve the prescribed air quality standards Municipalities are required to include an AQMP as part of its Integrated Development Plan.

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